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OF
CIVIL ENGINEERS

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14 Beacon Street, Boston

Vol. IV NOVEMBER, 1917 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, NOVEMBER 21, 1917,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Major George C. Whipple, President of the Society, will give an informal account of his journey to Russia as a member of the American Red Cross Mission.

Business of the Meeting. — To act on the following amendment to By-Law 5, submitted by members of former Nominating Committees:

Section 5 of the By-Laws to be amended to read as follows:

5. NOMINATING COMMITTEE AND ELECTION OF OFFICERS.

Whenever officers of the Society are to be elected by ballot, nominations shall be made by a Nominating Committee of nine, of whom three shall be the three latest Past Presidents who continue to be members of the Society and are not members of the Board of Government, and six shall be elected by ballot. *At the annual meeting in 1918, six members of the Nominating Committee shall be elected in accordance with the provisions of the existing By-Laws governing the elections of officers, except that only twelve candidates shall be nominated; the three candidates receiving the highest number of votes to serve two years; the three receiving the next highest number of votes to serve one year; there-*

*after,** three members of the Nominating Committee shall be elected at each annual meeting to serve two years each.

The Nominating Committee shall organize and act under its own rules. It may make nominations whether at the time it consists of nine members or of less, but the approval of at least six members of the Nominating Committee shall be required for a nomination.

The Nominating Committee shall prepare a list of its nominations for the officers to be elected at the annual election, and the Secretary shall mail this list to each member of the Society at least nine weeks before the annual meeting. An additional nomination for any office may be made by any twenty-five members of the Society who sign a nomination paper to that effect and file it with the Secretary at least six weeks before the date of the annual meeting. The Secretary shall print no nomination on any list or ballot until he has received notice in writing that the nomination is made with the knowledge and consent of the nominee. At least four weeks before the day of the annual meeting, letter-ballots shall be sent by the Secretary to each member of the Society, bearing the nominations made by the Nominating Committee, and also any which have been received on nomination papers as above provided, which latter nominations shall be distinguished in some convenient way from those made by the Nominating Committee. The ballot shall state the hour at which polls will close on the day of the annual meeting.

When returned to the Secretary, each ballot shall be enclosed in two envelopes, the inner one to be blank, and the outer one to be endorsed by the member's signature. The President shall appoint two tellers who shall canvass all ballots, and the result shall be announced at the annual meeting.

Of the candidates for any office at the election at the annual meeting, the one having the largest number of legal votes by letter-ballot shall be elected. Should there be a failure to elect any officer on account of a tie, the meeting shall proceed to elect such officer by ballot from among the candidates so tied, a majority of the votes cast being required to elect.

At any meeting of the Society, a vacancy for the unexpired term of an elected officer or a member of the Nominating Committee may be filled by ballot, provided the Nominating Committee gives notice in the call for the meeting of its nomination or nominations for such vacancy, a majority of the votes cast at the meeting being necessary to elect.

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* The preceding words beginning "At the annual meeting" shall be effective as an amendment of the By-Laws only from the date of passage until after the annual meeting in 1918. The remainder of these amendments shall go into effect after the annual meeting in 1918.

Whenever a President, Vice-President, Secretary or Treasurer is to be elected, the Nominating Committee shall nominate one candidate for each office to be filled. Whenever a Director or a member of the Nominating Committee is to be elected, the Nominating Committee shall nominate two candidates for each such office to be filled. Ballots shall provide space for the writing or pasting in of additional names by the voters.

S. E. TINKHAM, *Secretary*.

PAPERS IN THIS NUMBER.

Discussion of " History and Present Status of the Concrete Pile Industry."

" Lines and Grades in Tunnels of Small Diameter." Henry B. Pratt.

Memoir of Deceased Member.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
" Continuous Beams of Unequal Spans."	F. S. Bailey.	Oct.	Dec. 10.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, October 17, 1917.— A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by Vice-President Lewis M. Hastings.

There were 75 members and visitors present.

The reading of the record of the last meeting was dispensed with, and it was approved as printed in the October JOURNAL.

The Secretary reported for the Board of Government that it had elected to membership in the grade of member, Messrs. Theodore Reed Kendall and Albert Joseph Leavitt.

The Secretary announced the death of Frank A. Pierce, a member of the Society, which occurred on August 7, 1917. By vote, the chair was requested to appoint a committee to prepare a memoir, and Mr. George A. King has been appointed.

The speaker of the evening, Mr. Henry I. Harriman, president of the New England Power Company, was then introduced. Mr. Harriman read a most interesting paper entitled "Water Powers of New England." The paper dealt not only with the water powers of the New England Power Company, but with other hydroelectric developments and economic questions that underlie their construction and utilization.

At the conclusion of the reading of the paper, Mr. Harriman had thrown on the screen a large number of pictures showing numerous hydroelectric plants already in operation and others during their construction, not only in the New England states but on the Pacific coast.

A general discussion followed, in which Messrs. Barrows, Porter, Stearns, Safford and others took part.

After passing a vote of thanks to Mr. Harriman for his courtesy in presenting before the Society his most interesting paper, the meeting adjourned.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[November 1, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Bunker, Page Scribner, Fitchburg, Mass. (Age 42, b. Menomonie, Wis.) Student for one year, 1892–3, at University of Wisconsin, and for one quarter, 1896, at University of Chicago; graduate of University of Montana, 1904. From 1900 to 1901, one and one-half years, with Northern Pacific Ry. Co.; from 1904 to 1905, with U. S. Dept. of Interior, General Land Office (Montana), on reconnaissance, supervision of timber cuttings, etc.; from 1905 to 1914, with U. S. Dept. of Agriculture, Forest Service (Montana), on surveying, map making, road construction, design and construction of bridges and buildings, etc.; from 1914 to 1917, superintendent of parks and forester with city of Fitchburg; is now on leave of absence as Captain, O. R. C., U. S. Army. Refers to G. H. Chase and E. E. Lothrop.

Robinson, Ashley Quincy, Newton, Mass. (Age 24, b. Webster, Mass.) Educated in public schools and in office of father, Charles F. Robinson, C.E., Attleboro, Mass. From 1908 to 1912, rodman and transitman with C. F. Robinson; from 1912 to June, 1913, and from May to December, 1914, inspector on sewer construction with J. J. Van Valkenburgh; employed in same capacity by Metcalf & Eddy from August, 1913, to May, 1914; from December, 1914, to September, 1915, transitman and draftsman with C. F. Robinson; from September, 1915, to date, transitman and draftsman with Engineering Department, City of Newton. Elected a junior June 10, 1914, and now desires to be transferred to grade of member. Refers to I. W. Hastings, F. A. Marston, W. P. Morse, S. A. Nash, E. H. Rogers, J. J. Van Valkenburgh and J. P. Wentworth.

LIST OF MEMBERS.

CHANGES OF ADDRESS.

Alden, Frederick T.........................75 Elm St., Malden, Mass.

Blake Edmund M.,
Supervisor of Sub-Contracts, Abertaw Construction Co., Squantum Destroyer Plant, Atlantic, Mass.

Brock, Nathan S.......................208 Fuller St., Brookline, Mass.

Brown, H. Whittemore,
2d Lieut., E. O. R. C., 301st Engineers, Camp Devens, Ayer, Mass.

Burroughs, Russell .... B. & M. R. R., Nashua, N. H.
Carter, Frank H. .... 14 Clifton St., Cliftondale, Mass.
Clapp, Sidney K. .... Grand Gorge, N. Y.
Craigue, Joseph S., Capt., Engineer Corps, American Expeditionary Force, France
Crosier, Charles L. .... Hilltop Y. M. C. A., Pittsburg, Pa.
Delano, Ray O. .... B Co., 301st Engineers, Camp Devens, Ayer, Mass.
Farrell, Francis B. .... 158 Walnut St., Springfield, Mass.
Flett, Louis E. .... Worcester Y. M. C. A., Worcester, Mass.
French, Herman W. .... Randolph, Mass.
Hannah, Thomas E. .... 2d Lieut., C. A. C., Fort Monroe, Va.
Hurd, Stephen P. .... 836 Cleveland Ave., Bridgeport, Conn.
Katz, Harry L. .... 48 Mt. Vernon St., Cambridge, Mass.
McNulty, Richard J. .... 23 Nottingham St., Dorchester, Mass.
Mills, Hiram F. .... 314 Main St., South Hingham, Mass.
Nelson, William .... 37 Osborn St., Cambridge, Mass.
Porter, Arthur P. .... care Stone & Webster, 147 Milk St., Boston, Mass.
Sawyer, George S. .... 49 Oak Square Ave., Brighton, Mass.
Smith, William H. .... 2101 Brookfield Ave., Baltimore, Md.
Whitney, Walter C. .... 1907 15th St. N. W., Washington, D. C.

DEATH.

Johnson, William S. .... October 27, 1917

EMPLOYMENT BUREAU.

The Board of Government has established an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

412. Age 34. Graduate of Mass. Inst. of Technology, 1906, civil engineering course. Experience includes about four years as rodman, draftsman, estimator and designer with Charles River Basin Commission, and about three years as draftsman and estimator with State Highway Commission; has passed civil service examination as assistant engineer; is familiar with recent practice in sewerage work. Salary desired, $30 per week.

413. Age 41. Received technical education at Mass. Inst. of Technology. Has had eighteen years' experience on design and construction of street railways, water works, conduits, buildings and tunnels, including seven years as engineer of maintenance of way with street railway company on track, overhead lines and structures, and two years on water works. Desires position as superintendent of construction. Salary desired, $350 per month.

414. Age 28. Graduate of Harvard College, 1910, civil engineering course, specializing in railroad and hydraulic engineering. Experience consists of two years with N. Y., N. H. & H. R. R. on electrification work; one year on enlargement of hydroelectric development, design and construction work; six months on town and land court surveys; one year as safety inspector for insurance company on all kinds of construction work; and two years with Interstate Commerce Commission on railroad valuation, both field and office work. Desires position either on construction work or with large industrial concern, where technical education and experience are of value. Salary desired, $1 800 per year.

415. Age 21. Attended public and preparatory schools; student for two years at Middlebury College, Vt. Experience consists of work during vacations with engineering firm in Barre and Montpelier, Vt.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Absorption of Methane and Other Gases by Coal. S. H. Katz.

Answers to Questions on Flotation of Ores. Oliver C. Ralston.

Carbon Monoxide Poisoning in Steel Industry. J. A. Watkins.

Coking of Illinois Coals. F. K. Ovitz.

Extraction of Gasoline from Natural Gas by Absorption Methods. George A. Burrell and others.

Increased Yield of Turpentine and Rosin from Double Chipping. A. W. Schorger.

Limits of Complete Inflammability of Mixtures of Mine Gases and of Industrial Gases with Air. George A. Burrell and Alfred W. Gauger.

Mechanical Properties of Woods Grown in United States. J. A. Newlin and Thomas R. C. Wilson.

State Highway Mileage and Expenditures for Calendar Year 1916.

Substitution of Other Materials for Wood. Rolf Thelen.

State Reports.

Massachusetts. Annual Report of Highway Commission for 1915.

Rhode Island. Annual Report of Public Utilities Commission for 1916.

Municipal Reports.

Altoona, Pa. Annual Report of Director of Accounts and Finance for 1916.

Chicago, Ill. City Manager Plan for Chicago, 1917.

New York, N. Y. Annual Report of Board of Water Supply for 1916.

New York, N. Y. Annual Report of Department of Plant and Structures for 1916.

New York, N. Y. Catskill Water Supply: General Description and Brief History, 1917.

New York, N. Y. Report on Main Drainage and Sewage Disposal of Area Tributary to Jamaica Bay, 1917.

Miscellaneous.

American Society of Mechanical Engineers. Transactions for 1916.

American Society of Municipal Improvements. Proceedings for 1912, 1914, 1915 and 1916.

Business Law for Engineers. C. Frank Allen. Gift of author.

Elements of Hydrology. Adolph F. Meyer.

Engineering for Masonry Dams. William Pitcher Creager.

Government Ownership of Public Utility Service Undertakings. Los Angeles, Cal., City Club.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.* — Work is in progress on a transmission line between the Wachusett and Sudbury power stations, and approximately one third of the wooden poles have been erected for a distance of about five miles and concrete foundations for two of the steel towers are in place.

METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work in progress: Section 98 and Section 102, Wellesley Extension, Deer Island Outfall Sewer.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

Old Colony Parkway. — Construction of a temporary bridge across the Neponset River between Boston and Quincy.

BOSTON TRANSIT COMMISSION. — *Dorchester Tunnel.* — The following work is in progress:

Section F. The interior finish of the station and the construction of a prepayment surface station in Broadway for the interchange of passengers between surface cars and the tunnel.

Section G. Emergency exit at the pump-well, corner of Dorchester Ave. and West 5th St.; construction of bridge over the tracks of the New York, New Haven & Hartford R. R. Co. leading to the docks; ventilating chamber and emergency exit near West Seventh St.

Section J. The interior finish of the station and the construction of a surface station for the interchange of passengers between surface cars and the tunnel.

City of Boston. — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets:

SOUTH BOSTON.

Ralston St.,	from Dorchester Ave. to Old Colony Ave.	Macadam.

East Boston.

Neptune Rd.,	from Bennington St. to R. R.	Asphalt.
Gove St.,	from Cottage St. to Venice St.	Topeka.
Maverick Sq.,	from Summer St. to Maverick St.	Asphalt.

Brighton.

South St.,	from Commonwealth Ave. to Chestnut Hill.	Asphalt.
Brighton Ave.,	from Commonwealth Ave. to Cambridge St.	Asphalt.
Langley Rd.,	from Breck Ave., easterly.	Asphalt.
Breck Ave.,	from Washington St. to Langley Rd.	Bituminous macadam.

West Roxbury.

Richwood St.,	from Centre St. to Montview St.	Asphalt.
Brown Ave.,	from Poplar St. to Blakemore St.	Artificial walks.
Paul Gore St.,	from Number 12 to Chestnut Ave.	Artificial walks.
Ridge St.,	from Brown Ave. to Sycamore St.	Artificial walks.

Dorchester.

Hilltop St.,	from Granite Ave. to Hallett St.	Bituminous macadam.
Dorchester Ave.,	from Savin Hill Ave. to Freeport St.	Granite blocks.
Dorchester Ave.,	from Peabody Sq. to Washington St.	Granite blocks.
Dorchester Ave.,	from Freeport St. to Park St.	Granite blocks.
Norfolk St.,	from Corbett St. to Blue Hill Ave.	Asphalt.
King St.,	from Adams St. to Neponset Ave.	Artificial walks.
Adams St.,	from King Sq. to Ashmont St.	Artificial walks.
Adams St.,	from Codman St. to Richmond St.	Artificial walks.
Romsey St.,	from Dorchester Ave. to Sydney St.	Artificial walks.

Roxbury.

Lamartine St.,	from Boylston St. to Green St.	Artificial walks.
Wensley St.,	from Bucknam St. to Bickford St.	Bituminous macadam.
Overland St.,	from Brookline Ave. to B. & A. R. R. bridge.	Granite blocks.
Pontiac St.,	from Tremont St. to Hillside St.	Bituminous macadam.

City Proper.

Beacon St.,	from Tremont St. to Charles St.	Granite block.
Blossom St.,	from Allen St. to Fruit St.	Asphalt.
North Russell St.,	from Cambridge St. to Eaton St.	Asphalt.
Washington St.,	from Court Ave. to Beach St.	Wood block.
Hanover St.,	from Court St. to Commercial St.	Artificial walks.

New York, New Haven & Hartford R. R. Co. — *South Boston Cut Improvement.* — Enlargement of South Boston cut to Boston Freight Terminal to accommodate four tracks instead of two, and reconstruction of eleven overhead highway bridges, so as to span four tracks instead of two, progressing.

Steam shovel and gravel train have started work at the westerly end, and have advanced to West 6th Street excavating for additional tracks.

Vol. IV NOVEMBER, 1917 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

DISCUSSION OF "THE HISTORY AND PRESENT STATUS OF THE CONCRETE PILE INDUSTRY."*

BY THOS. W. CLARKE, LINTON HART, H. E. SAWTELL, J. T. SCULLY, R. A. HALE AND C. R. GOW.

MR. THOS. W. CLARKE.† — Mr. Gow's paper on the "History and Present Status of the Concrete Pile Industry" is certainly interesting and fills a void in engineering literature on this important branch of foundation construction.

In looking over Mr. Gow's paper, I notice several things about which you may be interested in hearing a little more, in addition to points treated by him which I will discuss. Assuming that that is so, I have gathered together a few photographs showing work which has been done, and some of the methods employed to overcome a few of the difficulties which have been encountered.

My experience in driving concrete piles covers a period of almost twelve years, principally with that type of pile which Mr. Gow refers to in his paper as the "Cast-in-place" pile. My observation of the work of driving concrete piles extends over a much longer time, I having seen some experiments carried out in Europe in the latter part of the 90's in which pre-cast concrete piles were being driven. I also saw some work which was done in Southampton in connection with one of the graving docks, at about the same time, I believe.

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* Printed in the April, 1917, number of the JOURNAL.

† Vice-President and Engineer, New England Foundation Co., Inc., 70 Kilby Street.

The first "cast-in-place" piles which I saw being driven were in New York; I think late in the summer of 1904. At that time the Raymond system was being used on West 23d Street, and the Simplex system was being used at the corner of Beaver Street and Broadway.

I was of the impression, until I read Mr. Gow's paper, that the piles which I saw driven in France were being placed during the late summer of 1894, but it is evident I am in error, and it was later than this, because Mr. Gow in his paper states that concrete piles were not driven in France until 1896.

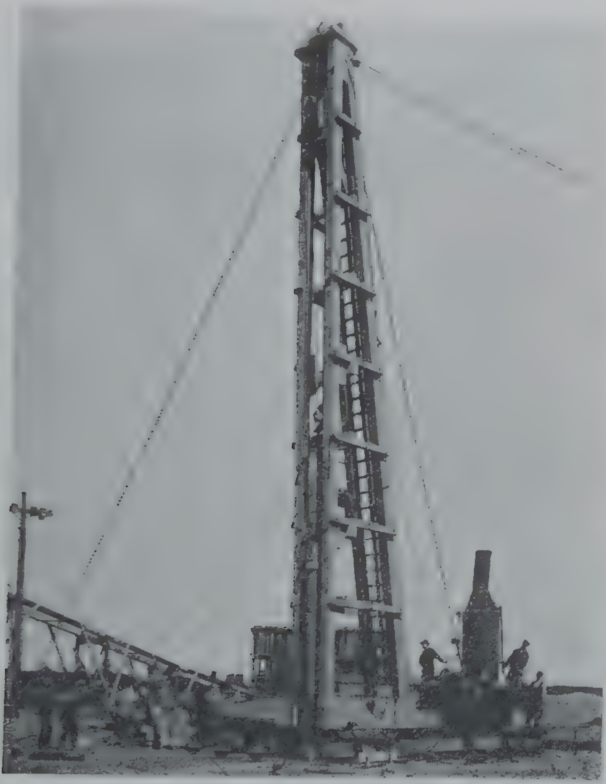
The use of concrete piles in important engineering structures has now become recognized by engineers as sound professional practice.

I think it is only fair at this point in my discussion to pay tribute to the engineers and others who have been directly connected with this industry, and who have had the courage to spend an enormous amount of capital, energy and time, in the face of innumerable and seemingly insurmountable obstacles. To-day the leading engineers and architects all over the world have been brought to a fuller realization of the true value of the various devices and methods which have been developed and used successfully in securing a firm, positive and lasting method of constructing foundations for permanent engineering structures.

Referring to Mr. Gow's paper: He refers, on page 160, to the different types of cushions or pile-driving caps used to cushion the blow of the hammer. The practice of using caps to cushion the blow has reached a state of great perfection to-day, but many of the methods mentioned by Mr. Gow have proved unsatisfactory and undesirable for this purpose, and I think I might quote from my own experience the difficulties encountered and the devices we have finally found which give the most satisfactory service.

The New England Foundation Company, Inc., whom I represent as engineer, has found, when driving piles using the Simplex system, that a cast-steel driving cap seems to give the best results. This cap weighs about 500 lbs. and is cast in such a way that it permanently retains itself in the leads and offers a guide to steady the upper end of the driving tube or form.

This driving cap has cast on its upper face, a cup-shaped receptacle about 7 ins. deep and 12 ins. in diameter. Into this receptacle is fitted a hard-wood block which acts as a cushion between the hammer and the cast-steel drive block. We have tried many kinds of wood for a cushioning material, the work being so hard that only a tough and fibrous material can be



Courtesy of New England Foundation Co., Inc., Boston, Mass.

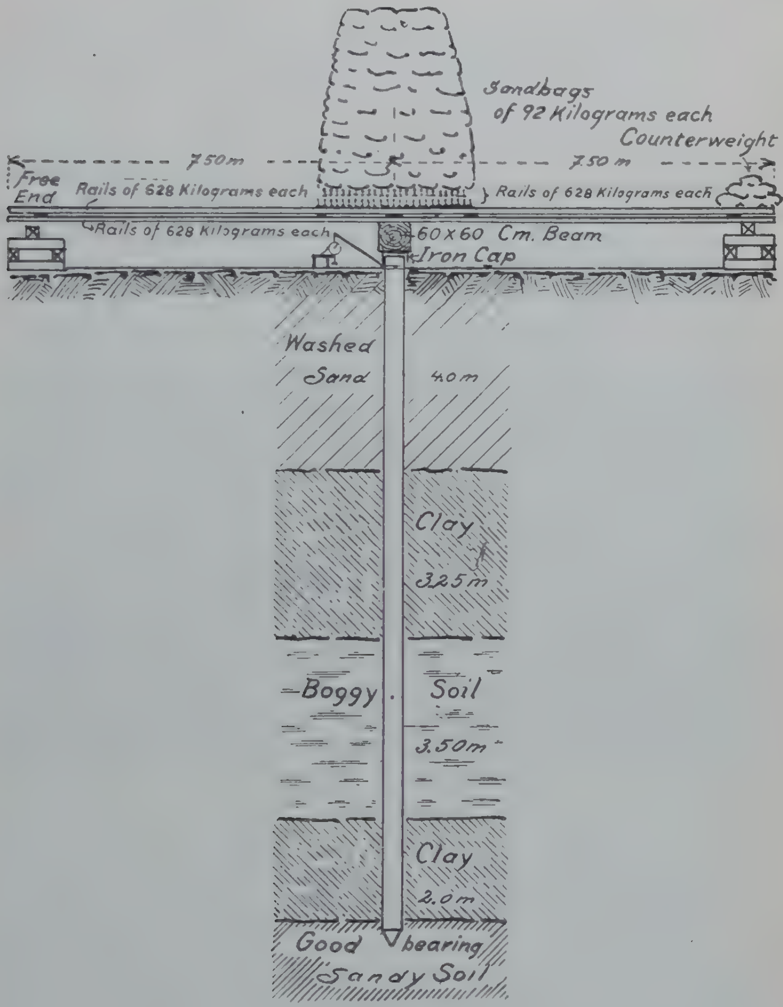
FIG. 1.

Standard Simplex Pile Driver, " Philadelphia Type." Gins 50 ft. from under side of head to bottom side of sole piece. Note that the driver is built without side braces, top being steadied with side guys controlled from the ground. This machine is built for drop hammer driving, with 40-ft. tube 16 ins. in diameter, and can drive piles over 60 ft. long, if necessary, using an extension tube.

used successfully. The timbers best meeting these requirements, and which can be obtained in this country, are oak, gum wood or hickory. In China, where I drove 10-in. piles using methods similar to the Simplex system, I used an Eastern wood, found in the Philippine Islands and Formosa, called Yacal, a very tough and hard wood not obtainable, I believe, in this locality. I experimented with many materials before settling on this cushioning wood, among others sand being tried, and also sawdust. Both of these materials quickly became very much compacted under the repeated blows of the hammer, so that after a few piles were driven they became so hard that it was necessary to blast them out of the drivehead, as it was impossible to cut them out with stonecutter's tools. Our practice in driving has shown us that the work performed by driving caps is considerable, it not being uncommon, when the material penetrated is extremely hard, for the drive blocks to catch fire from the heat created by the impact of the hammer. The method of shaping these wooden blocks and the size used seems to vary greatly with different contractors. We use a block which has a top diameter of about 10 ins., a middle diameter of about 14 ins., and a bottom diameter of about 10 ins., the taper of the block on the lower portion being such that it fits snugly into the cup-shaped receptacle on the upper face of the cast-steel drive head. The blocks we use are considerably larger than those generally used in steam hammers, but we consider this necessary as the amount of work performed per blow of the hammer is considerably more than that of the larger size steam hammers used for similar work.

Some steam hammer manufacturers use a wooden block banded with steel hoops to confine the material and keep it from being shattered or broomed under the repeated blows from the hammer.

On page 161, Mr. Gow refers to the different types of hammers used, but unfortunately does not give us much information in regard to the desirability of different types. I think that much can be said by contractors or engineers in favor or against any type which they have used on their work, and I can only cite from my own experience in regard to this important device so



Courtesy of Kohncke & Co., Bremen, Germany.

FIG. 2.

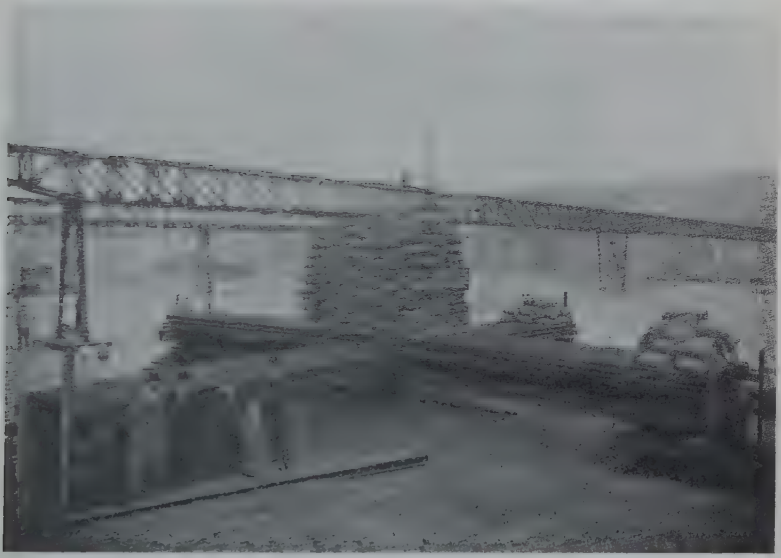
Sketch in detail showing method of construction used in placing test loads on 16-in. Simplex Concrete Piles. Tests were carried out under the direction of the Hamburg Public Works Department, Hamburg, Germany.

necessary to the penetration of the pile in the ground. I personally have used both the steam hammer and the drop hammer, and have observed the following points in favor or against their use:

The steam hammer, as it is to-day, is a very rugged and reliable piece of mechanism, and is capable, I believe, of driving a greater number of piles or a greater penetration of piling in one day than the drop hammer, except in very elastic or rubbery material similar to peat or gumbo clay; but it has some serious disadvantages as follows:

For a given amount of work the weight of a steam hammer is about three times that of a drop hammer. It requires a larger boiler to operate it, more coal per day, and more cost for the maintenance of the pipe line and hose which conveys the steam from the boiler to the cylinder of the hammer. It also requires more water when the hammer is in operation, and more oil for lubrication. I consider that the weight of the hammer is a very great detriment to its use, particularly so when the hammer must be raised to the top of the gins when starting to drive a new pile. At this particular time, you have added four or five tons aloft, greatly endangering the stability of the driver. The additional weight of the hammer and engine increases the difficulties encountered when moving the driver from place to place on the site of the work, and also requires the payment of more freight in transporting the equipment from one job to another. It may also be noted that it will require as large an engine and the same number of drums to operate successfully as are required when driving concrete piles with a drop hammer.

I have observed, as above referred to, that the steam hammer in certain kinds of soil does not seem to give high speeds in penetration in driving operations. I have in mind two jobs which were executed in Greater Boston, one job which was being driven by a contractor using a No. 1 Vulcan steam hammer, I believe; the other job, which was driven by ourselves, using a 3 300-lb. drop hammer with a 10-ft. drop. The character of the ground which was being penetrated showed that there was a fill of from 6 to 8 ft. of ashes and miscellaneous material. This overlay a peat bed with an average thickness, I believe, of 8 ft. The peat overlay a clay bed of varying thickness and consistency. Inasmuch as the two jobs were only about 800 ft. apart, and the material was practically of the same consistency, and as the borings on the two jobs showed similar conditions as regards thickness of the different strata, etc., it is reasonable to suppose that the work performed by the hammers on the two jobs was similar. On the job where the steam hammer was used, 240 to 280 blows of the hammer were required for the driving form to penetrate the peat, the speed in this case being about 60 to 65 blows per minute. The striking weight, I believe, was 5 000 lbs. and the drop 42 in. On our job, using a drop hammer, we penetrated the peat in from 12 to 16 blows at a speed of 30 blows per minute with a striking weight of 3 300 lbs.



Courtesy of Public Works Department, Hamburg, Germany, and Kohncke & Co., Bremen, Germany.

FIG. 3.

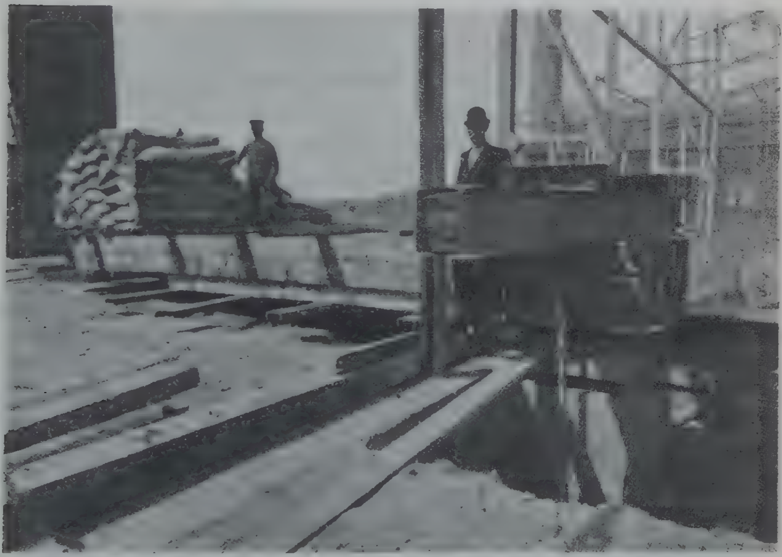
Usual method of testing Simplex Concrete Piles by Public Works Department, Hamburg, Germany.

Test load, 94 tons, on one 16-in. diameter pile. Note how the load is trimmed by the use of a few sand bags placed on the outer end of the two upper tiers of rails.

and a drop or free fall of 10 ft. It seemed to me at that time as if the steam hammer did not have kinetic energy enough to overcome the elasticity of the material which was being penetrated.

We also feel that the carrying capacity of the pile when driven by a steam hammer cannot be determined so reliably when using any of the many formulæ which purport to give the carrying capacity of the pile, in which the factors used are the penetration of the pile in a given number of blows, in conjunction with the weight of the hammer and its drop. Our reluctance to use the steam hammer and these formulæ can be understood when you consider the results as regards penetration in driving through elastic materials as observed above. It has been observed by other engineers who have used both the steam and drop hammer that the *Engineering News* formula for the drop hammer gives a safe carrying capacity for the pile, whereas its formula for steam hammers in some cases gives a dangerous carrying capacity. This can be best shown by referring to the *Engineering News*, Vol. 75, No. 1, January 6, 1916, page 33, in which a reference is made to comparative tests carried on at the Naval Dry Dock at Pearl Harbor, Island of Oahu, Hawaiian Islands, and also at the Naval Dry Dock, Mare Island Navy Yard, California, the article being entitled "Tests Comparing Steam and Drop Hammer Formulæ." I will not take space in this discussion to set forth this article, but only say briefly that Civil Engineer E. R. Gayler, U.S.N., considers, after testing piles from 80 ft. to 100 ft. long, driven with a penetration of from 40 ft. to 50 ft. without the use of follower (he having tested at Pearl Harbor nine piles driven with the drop hammer and eleven piles driven with the steam hammer in similar soil), that the steam hammer formula referred to above gives a dangerous value for carrying capacity of the pile.

The advantages in the use of a drop hammer we consider to be as follows: For a given amount of work the hammer is considerably lighter; for instance, a steam hammer of the Vulcan type would weigh about 10 000 lbs., whereas the hammer which we use and which is considered about equal in capacity to the hammer above cited would weigh 3 300 lbs. You do not have so much weight aloft nor so much mechanism to keep in repair and to maintain; there is no steam hose used, with its liability to delay operations by bursting or blowing off, nor pipe lines with the consequent radiation. You also have a device which is elastic, inasmuch as you can increase or decrease the intensity of the blow by increasing or decreasing the drop of the hammer. This is particularly desirable at times where it is advantageous to penetrate certain materials with either greater or less speed, as the occasion demands. The weight of the equipment, as pointed out above, is less, making it easier to move the driver over the ground and costing less when transporting the equipment from one job to another. On the other hand, I am willing to concede that a job cannot be driven with as great a speed in many cases as when using the steam hammer, but the advantages



Courtesy of Hamburg Public Works Department, Hamburg, Germany, and Kohncke & Co., Bremen, Germany.

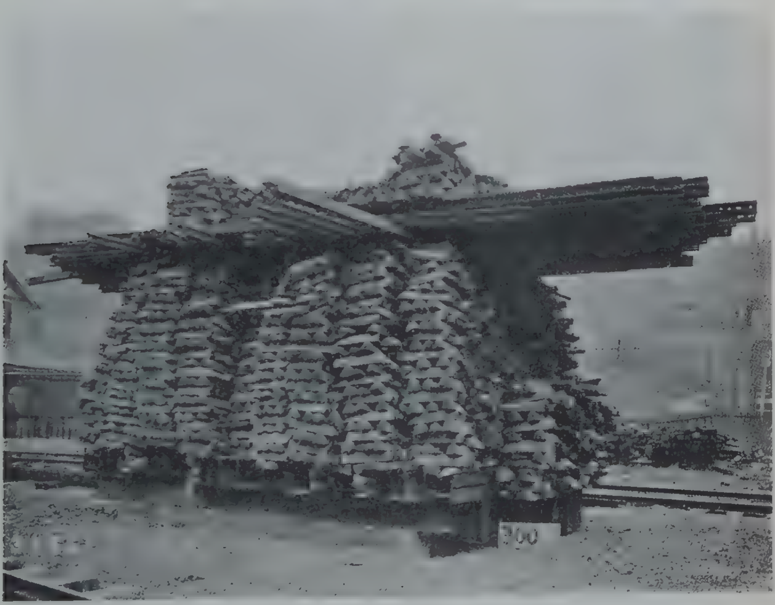
FIG. 4.

Testing Simplex Concrete Piles at Hamburg, Germany, using the cantilever method; load on pile, 88 tons. This work done under the supervision of the Hamburg Public Works Department. Note the small amount of material used to secure the desired load; also the length of the lever arm, about 30 ft. 0 ins.

gained in the reliability of the piles and their ability to carry the load more than offset the undesirable features cited above. I might also point out that the wear and tear of hammer ropes is considerable, involving additional expense in maintenance, more so, I believe, than in the maintenance of steam hose for the steam hammer.

On page 164, Mr. Gow refers to the straight-sided versus the tapered pile as regards the carrying capacity. There is one point that he has not mentioned in regard to the merits of straight-sided piles which is well known to engineers who have followed closely the different evolutions in connection with the development of the cast-in-place pile. The cast-in-place pile which is now on the market, and which uses a form with an extreme taper, does so primarily because they have found it impossible to build a device which they could collapse and withdraw from the ground easily, unless they used the tapered design, and as their mechanical construction requires this type of pile, they have taken advantage of this fact and made what they consider a strong talking point for their pile. I think the disadvantage of this type of pile can be best illustrated by citing a case which came under my observation wherein test piles were driven through about 11 ft. of loose fill into hard glacial drift which probably carried the entire load superimposed on the pile. In one case a taper pile was driven which had a penetration of about 17 ft. 6 ins., of which about 6 ft. 5 ins. was in the hard material. This pile where it entered the hard material had an area of about 90 sq. ins., which with a working load of 60 000 lbs. gave a stress on the concrete of about 667 lbs. per square inch; with the usual test load of 120 000 lbs., the stress on the concrete was about 1 333 lbs. per square inch, and in the case of the maximum test load which was applied to this pile, of 175 870 lbs., the stress was 1 954 lbs. per square inch. It is interesting to note that this pile commenced to show settlement ("$\frac{1}{8}$ of an inch") at 60 000 lbs. This continued progressively with every increment added until at the maximum test load the settlement was "$\frac{19}{32}$ of an inch." The surface area of the pile in the hard material, including the hemispherical point, was approximately 15.6 sq. ft. Referring to the stresses indicated above in the concrete, it is interesting to note that the stresses under working conditions in the pile where it entered the gravel were about 50 per cent. higher than are recommended by the American Society of Civil Engineers in their joint Report on Concrete, or allowed by the building authorities.

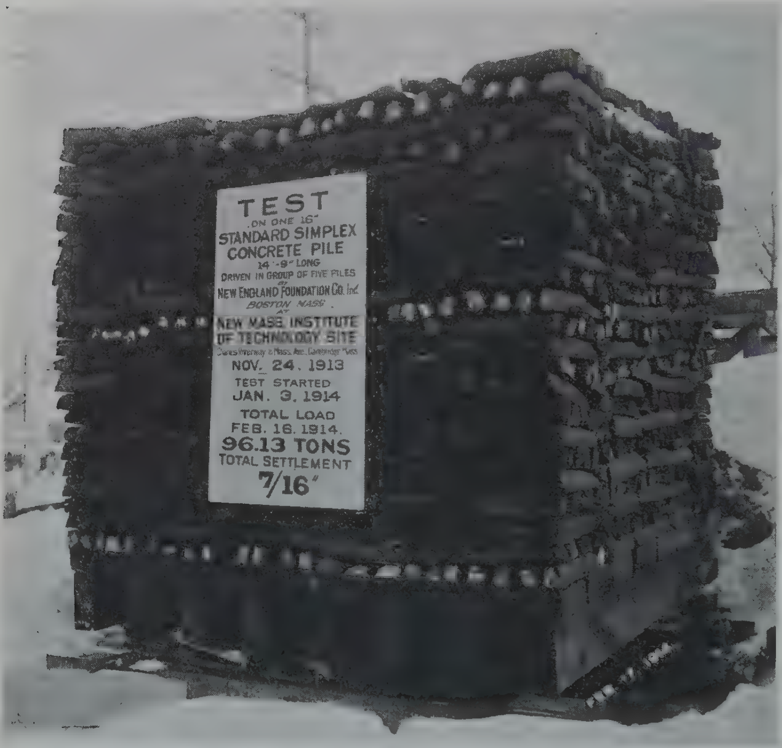
The other pile was of the standard Simplex type, straight sided and 16 ins. in diameter for its full length, and was driven within a few feet of the above test, at about the same time, having a penetration in the ground of 14 ft. 6 ins. This pile was driven into similar material of practically the same thickness, and had a penetration in the gravel of only 4 ft. The diameter of the pile where it entered the gravel was about 16 ins., giving a cross-sectional area of 201 sq. ins., which with a working load of 60 000 lbs. gave a stress on the concrete at this point of about



Courtesy of Cranford Construction Company, Pittsburg, Pa.

FIG. 5.

Method of loading 300 tons on five 16-in. Simplex Concrete Piles, tested at Westinghouse Machine Company, Pittsburg, Pa.



Courtesy of New England Foundation Co., Inc.

FIG. 6.

Method of loading 96.13 tons on one Simplex Concrete Pile tested at the Massachusetts Institute of Technology.

Testing plate, cast iron, 2 ins. by 24 ins. by 24 ins.

Two 15-in. 42-lb. I-beams 10 ft. 0 ins. long.

Eight 6-in. by 14-in. yellow pine beams, 10 ft. 0 ins. long.

Deck, eight 6-in. by 14-in. yellow pine, 10 ft. 0 ins. long.

Leveling rod, 1-in. pipe 15 ft. 0 in. long, grouted into pile, and extending up through deck and pig iron above top of load.

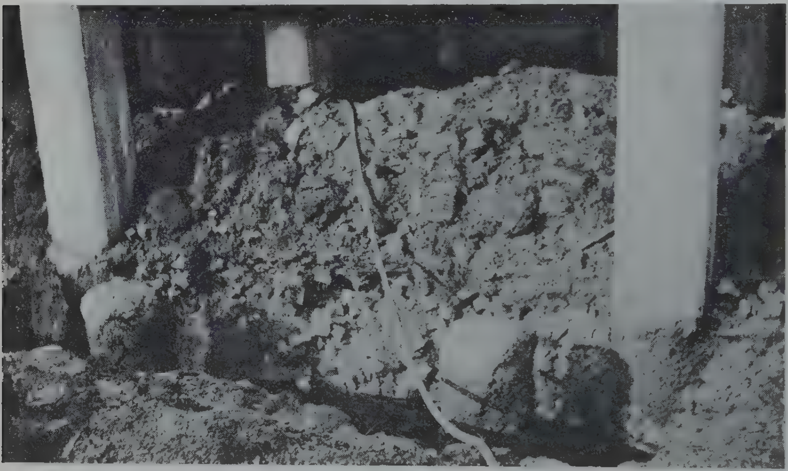
Load is balanced on the head of pile, which is well braced. Notice the 12-in. by 12-in. yellow pine timbers under the four corners of the load. Wedges are used between the top of these timbers and the yellow pine 6-in. by 14-in. beams which support the deck.

These wedges are used when loading the pile, the platform being wedged up after leveling, the test load being shifted until the pressure on the wedges is equal and the wedges can easily be removed by hand.

297 lbs. per square inch; with the usual test load of 120 000 lbs. this stress was about 595 lbs. per square inch, and with the load carried by the other pile of 175 870 lbs., the stress was about 875 lbs. per square inch. This pile carried a maximum load of 192 270 lbs., which gave a stress at this point of about 955 lbs. per square inch. It is interesting in this pile to note that it commenced to show a settlement ("$\frac{1}{8}$ of an inch") at 61 280 lbs; this settlement was observed to be "$\frac{3}{16}$ of an inch" at 85 800 lbs. and was not observed to increase until a load of 153 810 lbs. was on the pile, the observed settlement at this point being only $\frac{1}{4}$ in. The observed settlement, at the nearest increment to the maximum load on the taper pile at which readings were taken, was $\frac{9}{32}$ of an inch, being $\frac{5}{16}$ less than the other pile The observed readings at the maximum load was $\frac{7}{16}$ of an inch, being $\frac{5}{64}$ of an inch less than the other pile. The surface area of this pile in the hard material, including the conical point, was about 15.8 sq. ft., only $\frac{2}{10}$ of a square foot more than the other pile. The argument for the advantage of a straight-sided pile over a tapered pile under similar conditions seems to be proven in this case and is as follows: Lower stress in the concrete at the point where the load must be carried, larger compression of the soil, larger surface area of the pile, necessarily increasing its friction and carrying capacity, and, most important from the engineer's and owner's standpoint, a shorter pile is required for an equal load capacity, this of course involving less expense to the owner.

On page 177, Mr. Gow refers to the Simplex type of pile. I think perhaps you may be interested in knowing a little of the origin and history of this type of construction, particularly as it occurred in the early stages of the concrete pile industry.

In the fall of 1902, the U. S. Government was called upon to erect a group of buildings for the Engineer school at Washington Barracks, Washington, D. C. The site selected was very low swampy land, in which the overlying material was evidently of such a character that it was not considered possible to construct these buildings without serious settlement unless widely spread footings were used. The cost of going down to good bearing soil or the use of wooden piles cut off at the permanent water level was prohibitive and out of proportion to the cost of the superstructure. Capt. J. S. Sewell, Corps of Engineers, U. S. Army, who was directly responsible for this work, discussed one day his troubles with Mr. Cranford, a personal friend and a leading engineer in Washington, D. C., who in turn happened to mention the difficulties to Mr. Frank Shuman, a well-known designing engineer who happened to be in Washington at the time. When these difficulties were mentioned to Mr. Shuman, he replied immediately, " Why, that is easy; just punch holes in the ground and fill them with concrete." Mr. Shuman's remarks were received at that time as a jest. He, however, was not joking, and proceeded to make some experiments, and shortly afterwards placed a hastily rigged pile driver at the Washington



Courtesy of Galena Signal Oil Company, Bayway, N. J., and New York City.

FIG. 7.

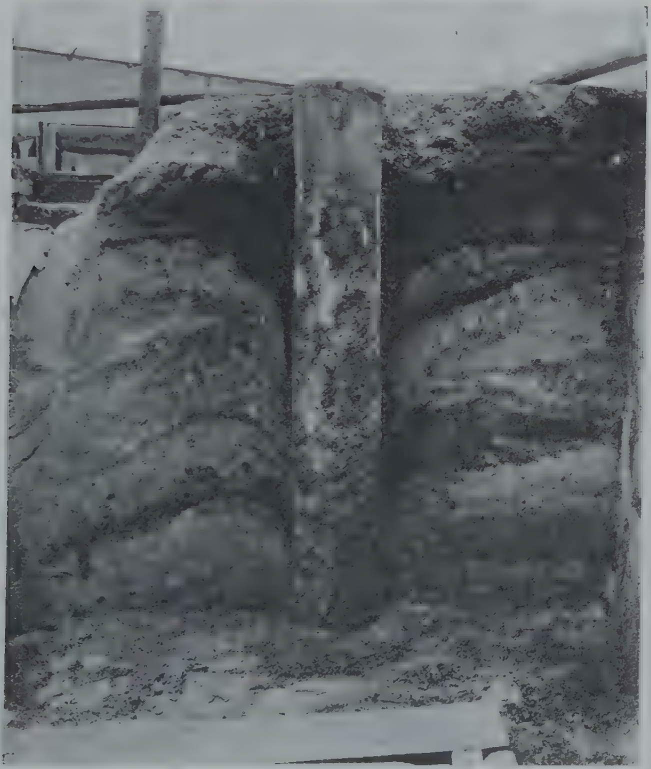
Simplex Concrete Piles extended up as reinforced concrete columns without the use of pile caps or footings.

Such jobs are possible only with concrete piles, as the uniform straightness and rigidity of the pile-forming apparatus allows great accuracy in driving the pile in the desired location.

Single piles were extended in this way to support a tank platform; maximum load on piles, tanks filled with water, about 45 tons. Piles driven to rock through the soft strata overlaying red New Jersey shale rock.

Piles driven for the S. T. Baker Oil Company at Bayway, N. J., by the Foundation Company, New York City.

Barracks for experimental purposes. The first experiments used a 10-in. extra heavy pipe, driving a tube with a conical point into the ground, the tube then being withdrawn and concrete being shoveled into the hole. This was found to be unsatisfactory and later changed by leaving the pipe in the ground and withdrawing it after the concrete had been poured. The



Courtesy of New England Foundation Co., Inc., Boston, Mass.

FIG. 8.

Exposure test on one 16-in. Simplex Concrete Pile driven in a group of one hundred twenty-one piles for a stack foundation at the Pacific Mills, Lawrence, Mass. See Fig 14.

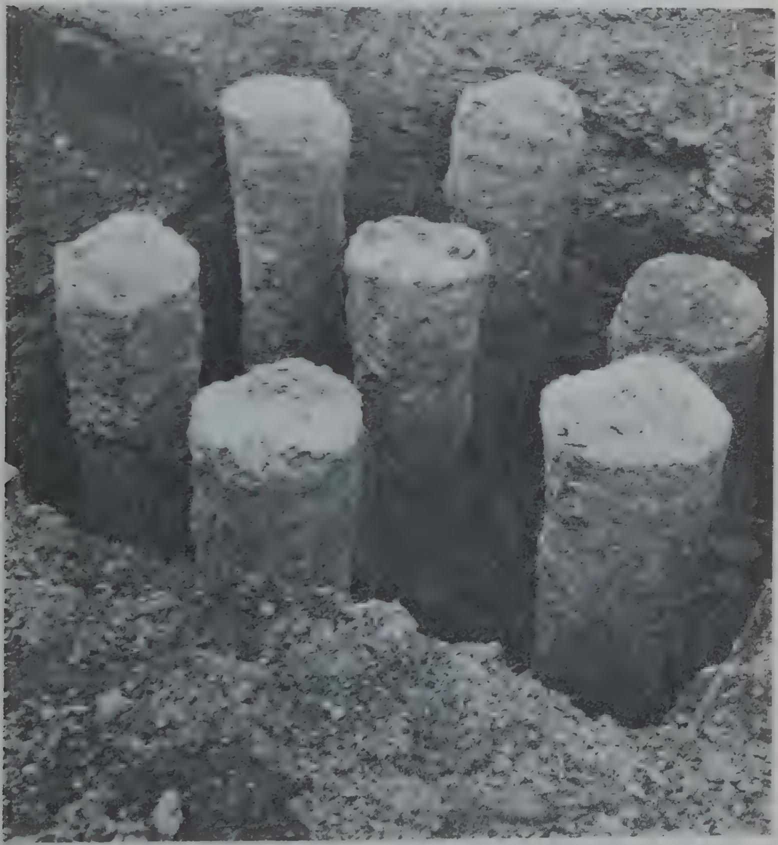
Note the rough surface of the pile, giving larger skin friction than with a smoother surface pile; also the action of the pile on the different strata of the earth, showing that the compression of the earth does not extend but a short distance from the outside surface of the pile.

buildings at the Navy Yard were constructed on piles driven in this way and are to-day standing intact without crack or settlement. The methods employed then were improved upon from time to time until those used to-day were evolved, so that now, as the result of a seeming jest, thousands of buildings and important engineering structures are standing all over the world built at a lower cost than would be possible under the old method of deep foundation or spread footing.

Continuing the discussion of the Simplex pile, Mr. Gow unfortunately mentioned in the text, and illustrated with cuts, two jobs showing distortion of cast-in-place piles. Fig. 29 on page 180 shows experiments carried out by Francis L. Pruyn, a well-known engineer in New York, who was endeavoring to find the faults or advantages of certain types of cast-in-place piles. This test was not driven using the Simplex system, nor were any men employed on this work who were familiar with the technique or methods used in driving the Simplex pile at that time.

Referring to the cut shown in Fig. 30, page 181, I will say that this work was on Fourth Street, New York. It was driven about 1912, by a contractor who used methods and apparatus entirely different from the Simplex system. I do not know whether or not the conditions shown in the cuts actually existed, as we were not at all interested in the matter, but I think it only fair to say that the methods which I understand were used at that time have been changed and that this type of pile has been considerably perfected.

Mr. Gow also mentions, on page 182, and illustrates in Fig. 31, conditions on a job in Chicago which was driven under the Simplex system, but under conditions in which the length of the piles driven was not under the control of the Cranford Construction Company, who were doing the work. This job was the Borland Building in Chicago, and was written up and the figure shown drawn by a man who was not familiar with the conditions at the site and was not in any way directly connected with the construction involved. This job resulted in a damage suit in which experts were called in, the ultimate outcome being that this method of construction was vindicated, and a decision was granted in favor of the contractors on this work. The evidence in this case, which included the testimony of "sand hogs" employed on this work, proved that the concrete piles were perfect throughout their entire length. Copies of the papers in connection with this job are at the office of the New England Foundation Company, Inc., and we shall be very glad to

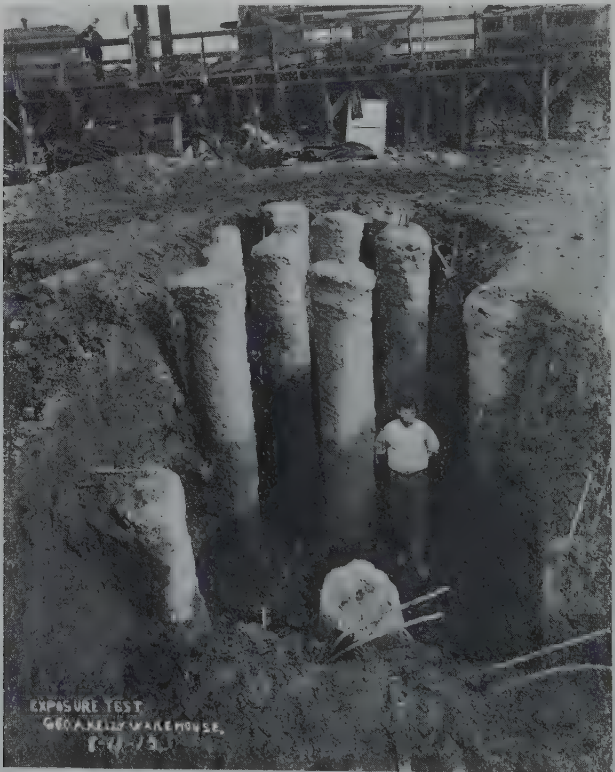


Courtesy of New England Foundation Co., Inc., Boston, Mass.

FIG. 9.

Exposure test Simplex Concrete Piles at the Young Men's Christian Association Building, Hartford, Conn. Piles driven 3 ft. 0 ins. centers, loading 30 tons per pile.

show them to any one who is interested in knowing what the conditions actually were. I have taken the liberty of citing this last case, as I think it only fair to the Simplex system to set forth the facts in detail, as the natural inference would be for one to assume that these jobs were all Simplex jobs, a condition that I am sure Mr. Gow did not intend to imply when he wrote this article.



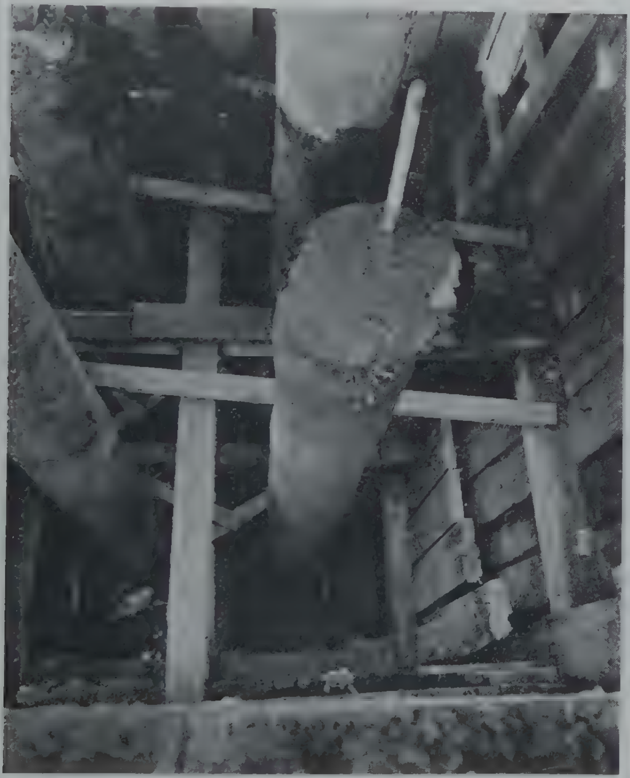
Courtesy of Cranford Construction Co., Pittsburg, Pa.

FIG. 10.

Exposure test on group of 16-in. Standard Simplex Concrete Piles driven for the foundation for the George A. Kelly Co., Pittsburg, Pa.

Note the rough surface of the pile, giving high frictional value; also the size of the pile compared to the man in the foreground.

In the Simplex concrete pile the cast-iron point is slightly larger than the tube, which is 16 ins. in diameter, while the cast-iron point is 16¾ ins. in diameter. The point is made in this manner so as to be sure that it will detach itself from the tube when the latter is withdrawn from the ground. Before driving, the point is calked watertight on the tube with rope yarn and grease. The effectiveness of this calking has been demonstrated many times by leaving the pile form unfilled after



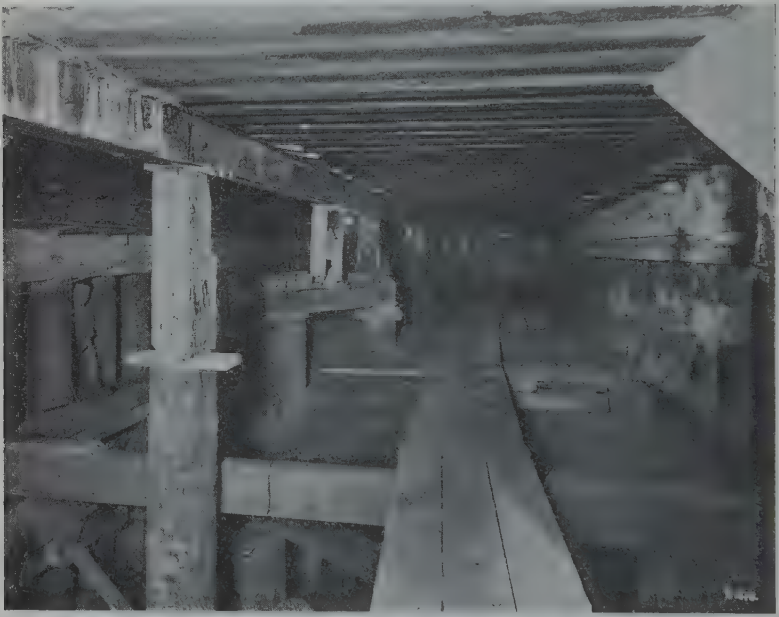
Courtesy of Cranford Paving Co., Washington, D. C.

FIG. 11.

Exposure test on four 16-in. Standard Simplex Concrete Piles driven for the foundation of the Baltimore Bargain Warehouse Co., Baltimore, Md. These piles 30 ft. 0 ins. long were exposed for 25 ft. 0 ins. of their length.

driving in the ground over night and finding the bottom dry in the morning even in water-bearing soil.

In driving the Simplex concrete pile, the different operations are as follows: The pile stake is removed from its location, the cast-iron point is set in the hole left by the pile stake, the pile driver is brought into position with the 16-in. driving form hung in the gins directly over the point, the driving form is lowered over the neck formed at the top of the cast-iron point, and driving operations are started with the drop hammer in the usual way. After the driving form has been driven to the desired penetration and the hammer and drive head have been



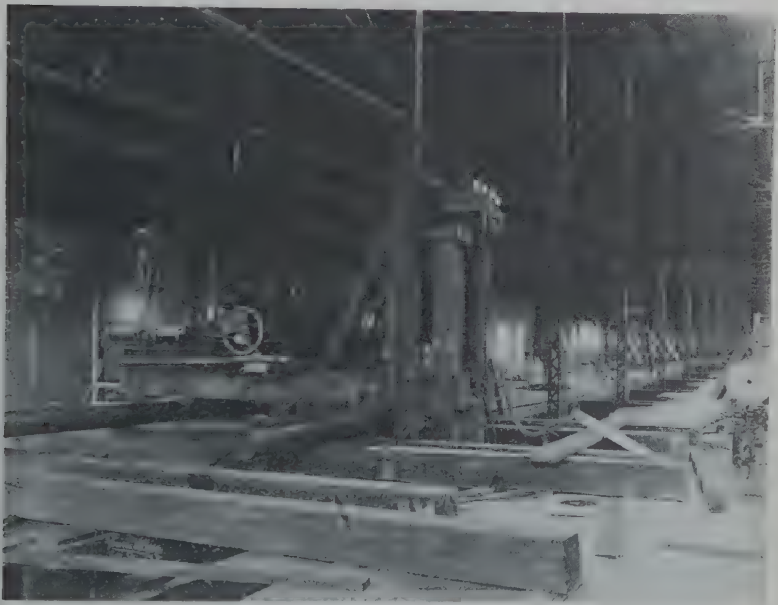
Courtesy of F. L. Cranford, Inc., New York City.

FIG. 12.

Sheet Steel Pipe Piles driven for underpinning under Trinity Church vestry, Church Street, New York City.

This work was undertaken by F. L. Cranford, Inc., engineers and general contractors for one section of the Tri-Borough Subway, and was carried out under the direct supervision and approval of the Public Service Commission, State of New York, Second District.

secured aloft, the form is filled part way with concrete and a strain is taken on the pulling apparatus. As soon as the form has been pulled six or eight inches, it is filled with wet concrete to a height of several feet above the surface of the ground. Inasmuch as the cross-sectional area of the tube wall is about 18 per cent. of the total cross-sectional area of the finished pile, it is always necessary when filling piles, which are to be finished at the surface of the ground, to fill them as above described. As the pile form is pulled, the wet concrete in the form feeds



Courtesy of Cranford Construction Co., Cincinnati, Ohio.

FIG. 13.

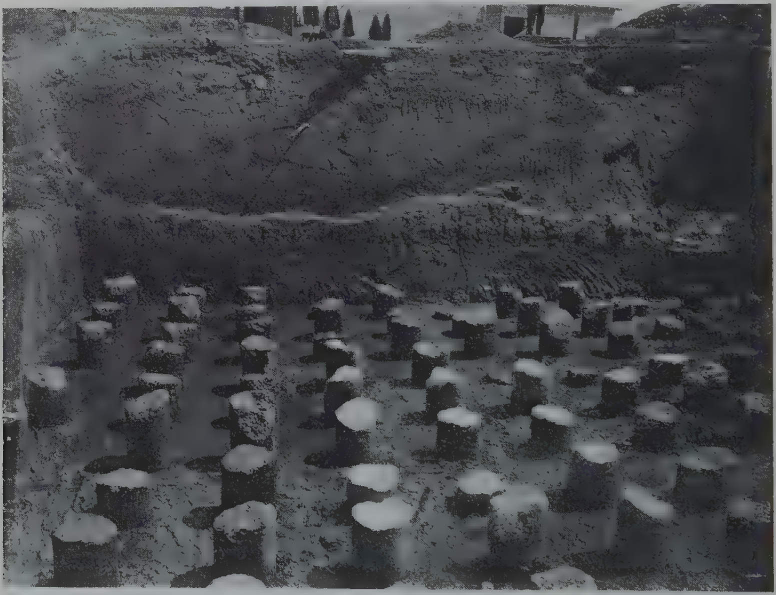
Reconstruction of the foundations under the Panhandle Freight & Warehouse Co., Cincinnati, Ohio.

The foundation under this building failed, threatening destruction of the structures, during one of the numerous floods in the Ohio River.

This building was conserved and the foundation reconstructed, using 16-in. Standard Simplex Concrete Piles 68 ft. 0 ins. long, driven in an available headroom of only 14 ft. 0 ins., using the extension tube method, the work interfering but little with the occupation of the building as a freight station and warehouse.

down, flowing out around the end of the form, cementing itself against the earth, thus filling the hole. The form when withdrawn leaves a perfect shaft of concrete 16 ins. in diameter resting on a cast-iron point.

The carrying capacity of the pile is usually arrived at by using one of the many formulæ which have for factors the weight of the drop hammer in conjunction with its drop and the penetration of the form. Inasmuch as most of these formulæ now used were intended primarily for use with wooden piles, it is evident that the results obtained, when applying these formulæ in the use of rigid steel driving forms, would show a lower carry-



Courtesy of New England Foundation Co., Inc., Boston, Mass.

FIG. 14.

Stack foundation at the Pacific Mills, Lawrence, Mass.

One hundred twenty-one 16-in. Simplex Concrete Piles driven 3 ft. 0 ins. centers both ways.

Note the perfect alignment of the piles always noticeable on cast-in-place pile jobs, due to the uniform shape of the cast-iron pile points and shape of the pile-forming apparatus.

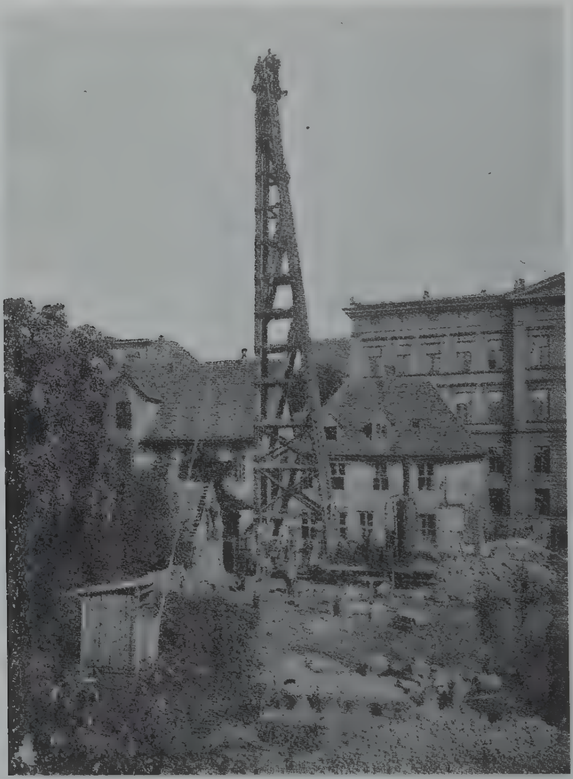
ing capacity than that which the pile really has, because, in driving the wooden pile, it may be observed that excessive vibration occurs (sometimes shattering the pile) which naturally prevents a large part of the energy developed by the hammer from reaching the point of the pile, whereas when using our pile-forming apparatus, which is very rigid, it is evident that a very much larger proportion of the energy of the hammer reaches the point of the pile.

Mr. Gow, in his paper, on page 183, refers to the rate of progress in driving Simplex piles. We know from experience, taking into consideration many jobs, that we average driving our piles in as good or better time than other contractors who drive the cast-in-place pile, and we or the others, and I say this unreservedly, can drive a given job with greater speed than is possible with the pre-cast type of pile.

Mr. Gow also refers to the severe strains brought upon the pile drivers because the tubes must be withdrawn from the ground after being filled with concrete, stating that it is not uncommon to lose a large amount of time on account of repairs to the equipment. Mr. Gow is in error, I believe, about this. In the first place, all cast-in-place pile-driving equipment is required to have enormous power to withdraw the tubes. We know that our machines, through many years of experience, are built more rugged, the mechanism is simpler, and I believe less time is lost on account of repairs to equipment, than in any other type of machine used in driving cast-in-place piles or concrete piles of any type.

On page 186, Mr, Gow compares the Peerless pile with the Simplex and Pedestal type, stating that it is not possible to drive Simplex or Pedestal piles over 50 ft. I cannot state as to the length it is possible to drive the Pedestal pile, but in the case of the Simplex, many jobs have been driven with a 50-ft. machine, using the extension tubes, in which the length of the finished pile was as high as 60 ft. In Germany, Kohncke & Co., licensees for the Simplex system, have driven many jobs over 50 ft., and one job in which the piles averaged 75 ft. $5\frac{1}{2}$ ins., the average penetration being 85 ft. 4 ins. The driver used for this work was about 95 ft. high. We ourselves have driven many jobs in which the piles were from 55 to over 60 ft. in length, and one job at Portland, Me., the longest pile was 67 ft., using a tube 76 ft. long and a driver which was about 85 ft. high.

On page 187, Mr. Gow refers to tubular piles which have been driven extensively in New York City. This type of pile is very expensive, due to the cost of the steel tubes or pipes, which are of necessity left in the ground, but on account of the



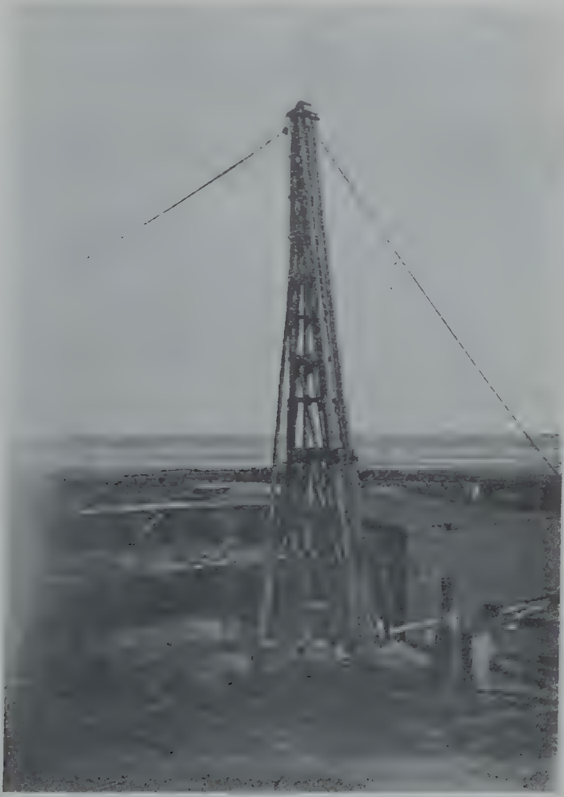
Courtesy of Kohncke & Co., Bremen, Germany.

FIG. 15.

Driving 16-in. Simplex Concrete Piles at Schwerin, Mecklenburg, Germany.

Penetration of driving form, 85 ft. 4 ins. Length of finished pile, 75 ft. 5½ ins.

geological conditions in New York, particularly on Manhattan Island, where these piles are mostly driven, very high loads can be carried, thus materially reducing the cost of the piles when considered on the per ton carrying capacity. The tubular pile is made up in several ways. One method is to use $\frac{5}{16}$-in. or

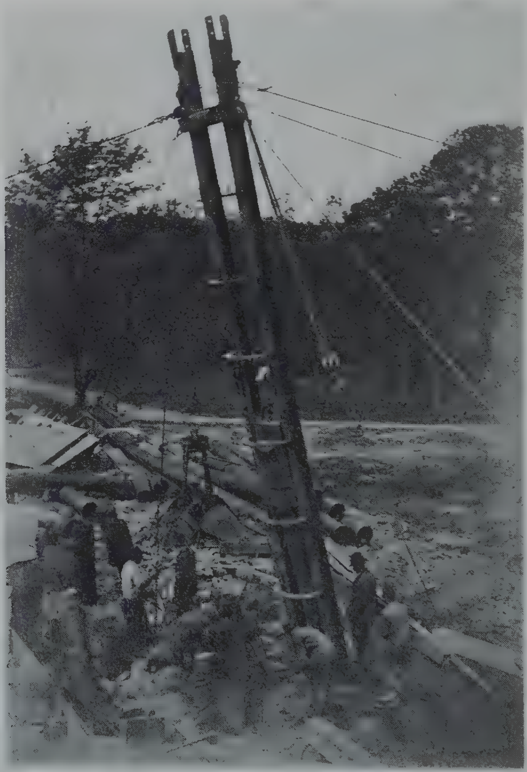


Courtesy of Portland Gas Light Co., Portland, Me.

FIG. 16.

Special Simplex Pile Driver. Gins, 80 ft. 0 ins. long from the under side of the head to the bottom side of sole piece. This pile driver was built using a 50 ft. 0 in. Standard Simplex machine, with a special detachable 30 ft. 0 in. section below. On account of the height of the machine, side braces were used as well as side guys. This machine used a 76 ft. 0 in. tube 16 ins. diameter, and drove piles 67 ft. 0 ins. long.

$\frac{3}{8}$-in. steel pipe in suitable lengths for handling, sometimes as short as 2 ft. for underpinning work, and where possible the full "random" length of 20 ft. or over. Another method is to drive a thin sheet-steel tube or pipe which is built up out of steel plates rolled up and shaped into a cylinder and riveted



Courtesy of New England Foundation Co., Boston, Mass.

FIG. 17.

Driving 14-in. Steel Pipe Piles without the use of a pile driver. Steel gins handled by derrick, desired batter obtained, and gins guyed securely in position. Drop hammer used operated by pile fall over derrick boom; engine at some convenient point. Cast-iron points were used, thus compacting the soil, increasing the carrying capacity and also saving excavating the pile.

Piles driven for the Metropolitan Park Commission at the Charles River Bridge, Norumbega Park, Auburndale, Mass., under the direction of John R. Rablin, engineer for the commission.

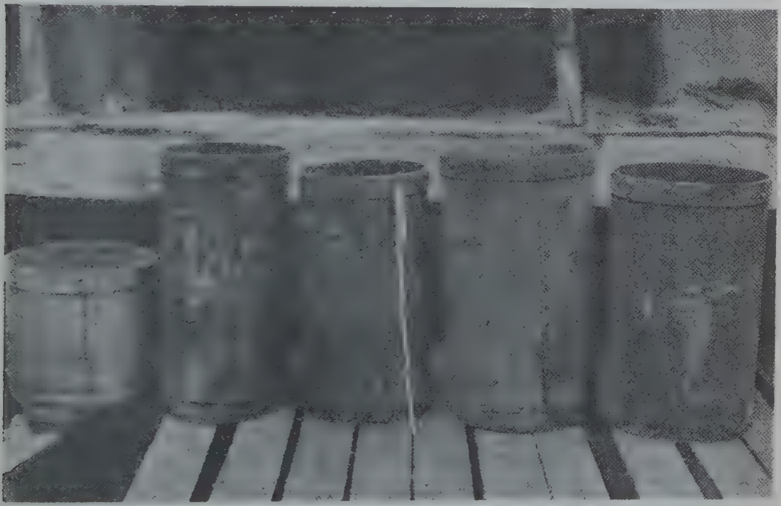
together. These are usually made in two-foot lengths with a thickness of metal of only $\frac{7}{64}$ of an inch.

Several ingenious methods have been devised for driving, excavating and filling these piles with concrete. In the case of the steel pipe piles above referred to, it is not usually a custom to erect a pile driver on the site, but where long lengths are driven, a four-legged timber frame is set up on the ground which has suitable cross bracing so arranged that it acts as guides to steady the pipe and keep it in a vertical condition while driving. A special hammer is used in which the power is furnished by compressed air instead of steam. This hammer has a specially designed base, which fits snugly over the top of the pipe. The pipe in this case has no point, the ends of the pipe forming a cutting edge. The pipe is driven into the ground to the desired depth, sometimes several lengths of pipe being put one on top of another, being coupled together with inside couplings or sleeves of cast-steel, having at their center a rib or outside projecting ring, the top and bottom faces of which are beveled towards the sleeve. The outside diameter of this rib is practically the same as the outside diameter of the pipe. The outside diameter of the sleeve or coupling is slightly larger than the inside diameter of the pipe. The purpose of this construction is to make this sleeve snug and watertight and yet crowd the ends of the pipe against the sleeve to prevent any tendency to split or telescope the pipe. This is done by the bevel of the rib on the top and bottom faces. Many other devices have been tried, but have been abandoned in favor of the sleeve described above. The sleeve shown on page 188 and described by Mr. Gow has been abandoned for some time.

After this pipe has been driven to the desired penetration, usually a slight distance into the rock formation, it is excavated, using a very ingenious pneumatic method. A large size pneumatic compressor is installed on the work, having one or more good-sized air flasks which are used to store air at about 90 lbs. pressure and give a tremendous volume instantly for the work to be done. This air is led from the flasks to the driven pipes through steel tubes of 3 or 4 ins. in diameter, and from the end of this tube through a flexible hose and a piece of 2-in. pipe long enough to reach to the bottom of the driven pipe. This is lowered into the interior of the driven pipe. The driven pipe is then filled to the top with water and a steel bit is churned up and down to loosen material inside of it as much as possible, and to allow the 2-in. air pipe to sink as far down as necessary into the interior of the driven pipe. Air is then turned on in the 2-in. air pipe, using a quick opening valve, giving the full volume of the opening immediately. A tremendous amount of air rushes through the pipe and discharges downward from the end of the 2-in. air pipe, loosening the material inside of the driven pipe. This tremendous volume of air lifts the material out, sometimes throwing it 15 or 20 ft. in the air. Bowlders are ejected from the driven pipe by this method which are sometimes over half its diameter. The speed with which this excavating can be done is remarkable. If ample air capacity is available, pipes 60 ft. long have been cleaned out in fifteen or twenty minutes bone dry, and the surface of the rock at the bottom has been removed where the rock is at all soft, ready for immediate concreting operations. If the steel tube projects above the desired elevation of the cut-off, the top is removed by cutting through the steel with an oxy-acetylene flame. The tube is then filled with concrete. All the equipment used on the work is handled with a stiff leg derrick or other suitable device.

The New York Building Department has written in their building laws, special provisions for this type of pile, having provided under Article 12, Paragraph 235, Subdivision 3A, in the New Building Code, specifications for concrete-filled steel tubes, which in substance state that the diameter shall be 9 ins. or more, the thickness of the steel walls not less than $\frac{5}{16}$ of an inch, the ends of the tubes faced perpendicular to the axis, and the splices of approved design. The length of any such pile, it is stated, shall not exceed forty times the inside diameter of the tube. The most interesting provision in this specification is that which takes into consideration the value of the steel tube as a supporting medium. This clause is as follows: "The allowable load shall not exceed 500 lbs. per square inch on the concrete and 7 500 lbs. per square inch on the steel, provided that in computing the effective area of the steel the outer $\frac{1}{16}$ of an inch of thickness shall be deducted from the thickness of the tube. No interior steel reinforcements shall be used." The deduction noted above of $\frac{1}{16}$ of an inch in the thickness of the tube was made after observation covering many years, of the corrosive action on the exterior surface of these pipe piles, and it has been determined that this corrosive action does not extend $\frac{1}{16}$ of an inch in from the outside surface.

The other type of steel pile described above is driven in an entirely different manner. These built-up steel tubes are usually made in two-foot lengths with a thin steel reinforcing band riveted on the outside at the top and a thin steel reinforcing band or sleeve riveted on the inside at the bottom, which projects 2 or 3 ins. below the bottom of the pipe. These pipes are set one on top of the other and driven into the ground without



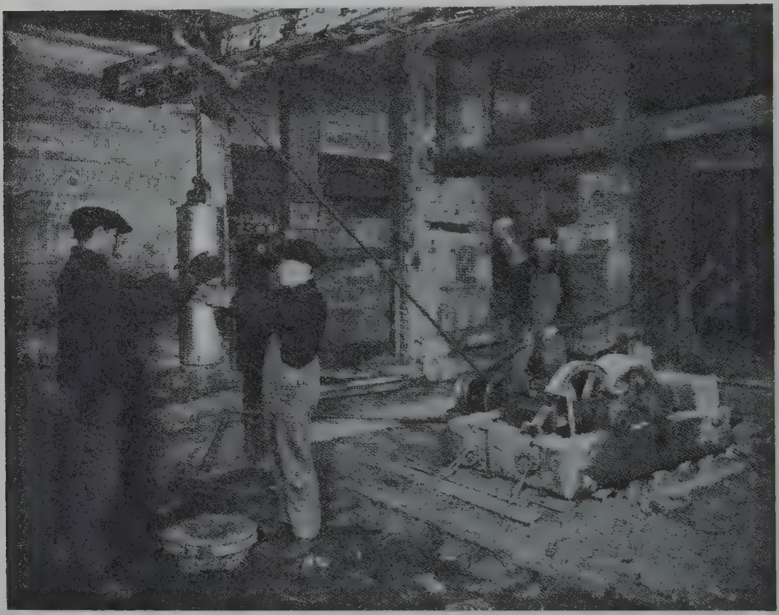
From "Modern Underpinning," by Lazarus White, C.E., and Edmund Astley Prentis, Jr., E.M.

FIG. 18.

Two sizes of approved sheet-steel pipe pile sections are shown, 12 and 14 in. diameters. Section on the extreme left is a so-called starter section. The two other types shown are so-called follower sections.

Over 100 000 ft. of this type of sheet-steel pile has been driven under the new Tri-Borough Subway, New York City, with the approval of the Public Service Commission, State of New York, Second District.

a point, the bottom end of the pipe forming the cutting edge. The method employed in driving is to put a cast-steel cap weighing about 250 lbs. over the top end of the pipe. On this is dropped a weight or hammer usually 9 ins. in diameter and weighing from 400 to 500 lbs. A very small amount of apparatus is used in driving. This consists of a snatch block, which is fastened at some convenient point directly over the pile, through which is led a manila hammer fall, one end of which is secured to the hammer, the other end passing around the nigger-



Courtesy of Public Service Commission, State of New York, Second District, and F. L. Cranford, Inc., New York City.

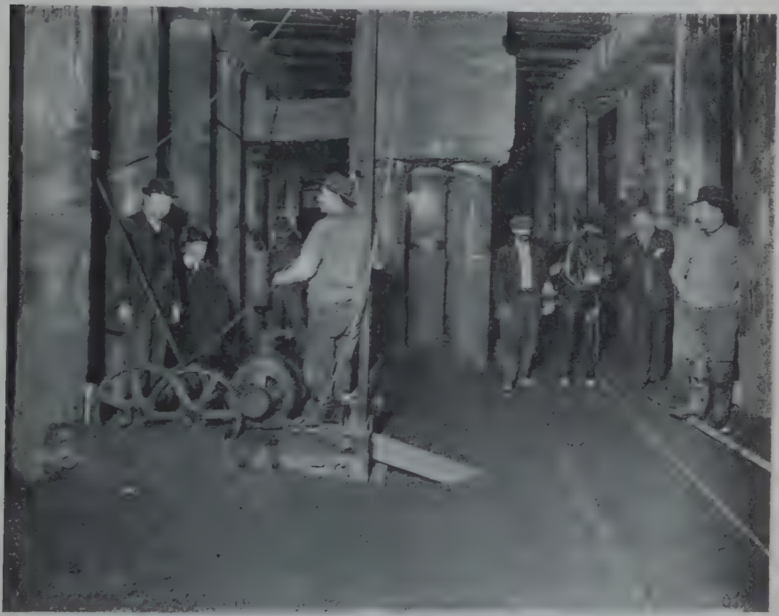
FIG. 19.

Driving 14-in. sheet-steel pipe piles to be filled with concrete after being excavated and cleaned out.

Note the drop hammer, weighing about 500 lbs., dropping three feet and guided by two men while striking the blow; also the electric winch in the background with the winch man operating the pile hammer fall over the winch head.

These piles were driven in the new Tri-Borough Subway, New York City, by F. L. Cranford, Inc.

head on a small electric winch. This winch is run at a steady speed, the hammer being raised or lowered by the winchman tightening or loosening the several turns of the hammer fall around the winch head. The hammer is guided in its drop of 2 ft. or 3 ft. by one or two men grasping the sides. It is not usual to drive any great depth at one time with this apparatus without excavating the interior of the pile. This is generally done by using one of two methods. If the material being penetrated is not very compact, a large jointed auger fitting loosely inside of the pipe is used, but this is not practical when the digging is any considerable depth below the men operating the



Courtesy of Public Service Commission, State of New York, Second District.

FIG. 20.

Driving 14-in. sheet-steel pipe piles in new Tri-Borough Subway, New York City.

Note the electric winch used to hoist the hammer, in the foreground, with the man guiding the hammer driving the pile directly in the rear.

Finished piles can be seen supporting the roof, also under the large pier in the center of the picture.

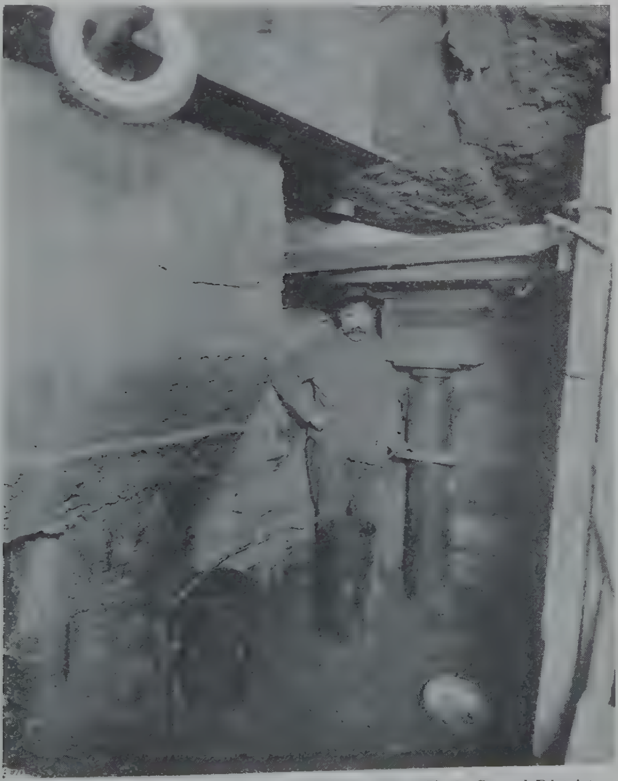
auger. If the material is compact or the digging is some distance below the top of the pile, a small orange-peel bucket is used. These buckets are small enough to open their full size inside of the pile, some buckets being made to open inside of a circle 10 ins. in diameter, others being made for 12-in. and 14-in. diameter circles. These buckets differ only from the larger size buckets with which we are all familiar in that they are fitted with a small ball weight which can be used as a hammer to drive the blades into the material to be excavated and also give additional weight to the bucket when it is being closed. These buckets can be operated over small pulleys by hand without the use of winch or other mechanical devices for pulling the lines, when closing and raising the bucket.

Several hundred thousand feet of piling have been driven under the new subways in lower New York within the last four years, using this method and this type of pipe pile.

Still another method is employed in driving steel-pipe piles, — the hydraulic system. This has been very clearly described by Mr. Gow, and I do not think it necessary to amplify this, except to say that at times very large rams and very high pressures are used. This is particularly so when it becomes necessary to drive the pipe with the lower end closed with a point. Of course the use of the point compacts the earth and considerably increases the resistance in driving. This last-mentioned process of driving is only used, I believe, where it is practically impossible to clean out the inside of the pipe for concreting. Difficult underpinning along the subway and under some of the high buildings in New York has been undertaken using this last method.

On page 189, Mr. Gow refers to the Compressol pile. This method was originated and perfected, I believe, by Mr. Hennebique, one of the pioneers in reinforced concrete construction in Europe, and I am glad to testify to the fact that he was also a pioneer in the concrete pile industry. Pre-cast piles were driven in France in the late 90's from designs prepared by him and under his direct supervision. The Compressol job referred to by Mr. Gow in his paper as having been driven at Perth Amboy, N. J., was work which was executed for the

Cheseborough Manufacturing Company. I am more or less familiar with this job, as the plans were submitted to me for my opinion when I was acting as consulting engineer for the Cheseborough Manufacturing Company. The character of the soil was such at this job, and the loads were so heavy and concentrated, that it was thought this type of pile would give excellent results. Although the methods used seemed very crude com-



Courtesy of Public Service Commission, State of New York, Second District.

FIG. 21.

Driving 12-in. steel-pipe piles with hydraulic jacks. Underpinning one of the skyscrapers along the route of the new Tri Borough Subway, New York City.

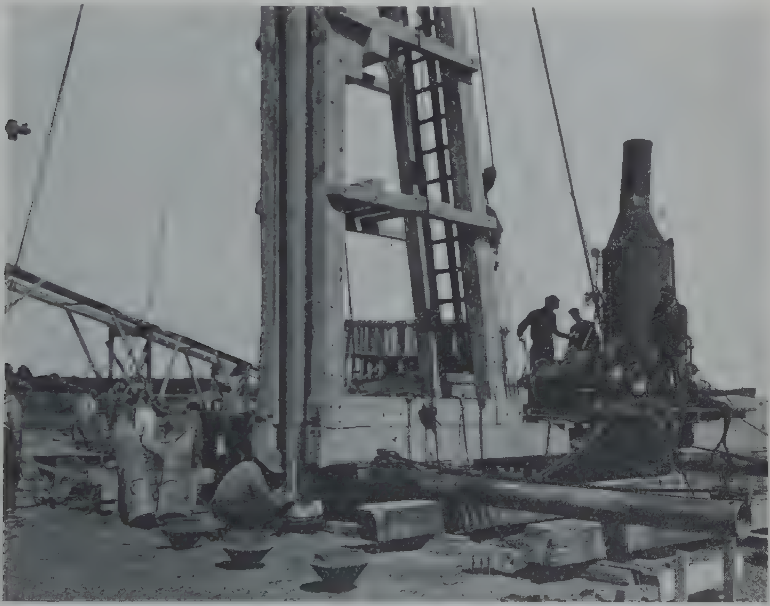
Note the hydraulic jack with the flexible copper pipe leading to the hydraulic pressure pump.

pared to methods employed by other concrete pile drivers, the results obtained were highly satisfactory and the buildings which were constructed on these piles were at last reports in excellent condition, without crack or settlement. I never have understood why more piles have not been driven in this country by use of this method, as it has evident merit.

There is another method employed in making concrete piles which originated in Belgium. This is the so-called Frankignoul pile which is driven using a series of tubes fitting one inside of the other, like a telescope. The lower ends of these tubes are closed with a point which can be controlled from the surface of the ground. This point engages an inside collar on the lower tube in such a manner that when the point is driven into the ground it drags the tube down with it. The tube on its upper end has an outside collar or projection which in turn engages an inside collar on the next length pipe in which the lower pipe telescopes. This method of constructing the tubes can be increased to an indefinite length, and piles, I believe, have been driven in Belgium to a considerable depth. The peculiar part about this method of driving piles is that the striking weight or hammer is so arranged that it strikes directly on the point, it being operated entirely inside the tube on a rod leading from the point. The piles formed by this method are very large in diameter, at times, I believe, as much as a meter across. I understand no piles have been driven by means of this method in the United States, although I think it was under consideration at one time by some engineering contractor in the Middle West. From photographs and data which I have in my office, I learn that one pile was driven at Liege, Belgium, with the mean diameter of 40 ins. The pile tapered from 50 ins. to 28 ins., the small diameter being at the bottom. It was loaded with 530 metric tons, equal to about 584 short tons. The total settlement was $1\frac{37}{64}$ ins.

Another method not mentioned by Mr. Gow is the Siegwart, a Swiss pile owned by the Siegwart Pile Company, of Lucerne, Switzerland. This pile is made by driving a tube about 16 ins. in diameter into the ground. After the desired penetration is reached, the tube is withdrawn about 5 ft. and a charge of dynamite is exploded in the ground, making a cavity at this point. This cavity and the tube are filled with concrete, thus forming a concrete pile with an enlarged base. These two last methods are described in the February, 1914, issue of the *Railway Engineer*, published in London, England.

Under the head of "Combination Piles," on page 194, Mr. Gow refers to the Ripley pile. This is a wood pile primarily for water work, which is covered with a protective coating of concrete, the purpose of which is to protect the pile from the attacks of the teredo and limnora. This concrete protection is now held in place, I believe, with suitable expanded metal or other reinforcement, but it is interesting to note in



Courtesy of New England Foundation Co., Inc., Boston, Mass.

FIG. 22.

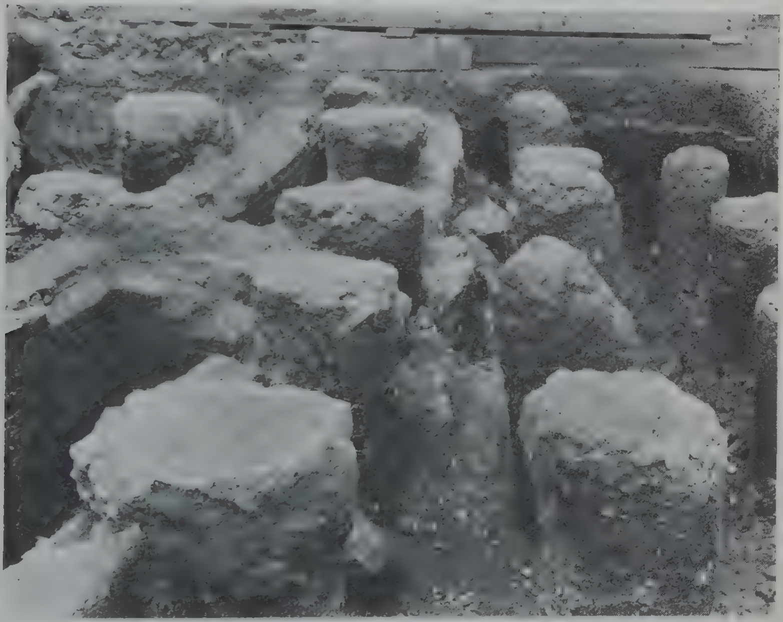
Standard Simplex Pile Driver, "Philadelphia Type." One of the operations in driving Simplex concrete piles—"setting the driving form on the cast-iron point." Note size of points in foreground. The form is fitted over the point without shifting its position. Note rugged construction of driver gins.

the early experiments conducted by Mr. Ripley, which I was fortunate enough to see, that the concrete protection was held in place by driving nails, the heads of which projected from the surface of the pile. These nails were driven thickly over the entire surface about 3 or 4 ins. apart on centers. I do not think much has been done on this type of pile.

Another interesting type of combination pile construction was built at Long Island City some years ago, where the Standard Oil Company of New York had a wharf which was destroyed by fire at one of their refineries, only that part of the piles below the water level being left, the deck of the wharf with all the bracing being burned off. It was decided to rebuild this structure with a permanent wharf which would be fire resisting. After considerable study it was decided to use reinforced concrete, building a structure on top of the old piles which were left. The old piles were sawed off at a uniform level and the tops were capped with a series of concrete beams and braces. This construction was extended up to the desired height, with reinforced concrete columns at each pile, and on this structure was built a reinforced concrete deck, making an effective wharf which is in use to-day and at which large steamers dock to receive their cargoes.

On page 199, under the heading " Selection of Type of Pile," Mr. Gow refers again to the Simplex pile. I think it would be of interest for your members to know that up to the time, a little over a year ago, when comparative records were prepared, more piles had been driven, taking into consideration the whole world as a territory, under the Simplex system than under any other distinctive system of concrete piling. The percentage driven in the United States and Canada is not so large perhaps as some of our competitors, but when taken in the aggregate, as above stated, and with the whole world as a field, I think the Simplex system stands well in advance of the field for the number of feet of penetration of piles driven. The results cited above have been obtained not only by the efforts of the engineers and contractors operating, using the Simplex methods in this country, but are also due to the progressive methods employed by foreign engineers and contractors in England, Russia, France, Italy, Greece, Belgium, and Germany, who have operated in all parts of the world using Simplex methods successfully.

On page 190, reference is made to the built-in-place piles which leave their shells permanently in the ground. Speaking of the tapered pile, I think it is proper to note that the value of the thin sheet-steel shell (No. 16 or No. 18 gage metal) which is drawn over the driving form is doubtful when driving in bowlder, hard gravel or shingle formation. At these times it is practically impossible to drive without rupturing this thin metal, thereby destroying its much advertised effectiveness as a protective shell. In water-bearing soil it is almost impossible



Courtesy of New England Foundation Co., Inc.

FIG. 23.

Simplex Concrete Piles driven into the wall of abandoned gas holder (pit type) at the Central Station, Boston Consolidated Gas Co., Roxbury, Mass., for stack foundation.

Note the center row of piles, which are driven into a stone wall about 10 ft. 0 ins. deep. Piles were about 30 ft. 0 ins. long and were driven successfully without injury.

to keep water out of this type of pile, or, in fact, any pile, unless the end is calked water-tight. All cast-in-place pile-driving equipment used by contractors driving other systems carry special syphons to remove the water which may get into the pile form after driving and before concreting. In using the Simplex system we never have trouble of this kind, so do not have this device on our work. It is impossible to pour a concrete pile successfully in a form which contains water. To use a phrase of one of our friends driving another system, "*That is what I call well-washed concrete.*"

It is interesting to note what seemingly great difficulties can be overcome when driving cast-in-place piles which use heavy, rigid, driving forms and heavy cast-iron points such as are used in the Simplex system.

We drove Simplex piles for the Boston Consolidated Gas Company for a boiler house, power house and radial brick chimney. At the time we took the work, which was let to us on a competitive basis, we were told that we might strike obstructions which would make the driving very difficult. During the driving, we discovered that the piles for the stack were directly over the outer wall of an old-style pit gas holder which had been built within a brick building. This outer wall was the foundation for the brick wall forming the sides of the building. The wall was dry laid and was built of Boston bluestone. Piles were driven in the desired location without regard to the obstructions known to be there. Several piles penetrated this wall for its full depth, which was about 10 ft., without great difficulty, and were found to be perfect in every particular. Other piles were driven through the brick bottom of the holder, which was about 28 ft. below the surface. This bottom was hard burned brick laid on cement mortar and was about 12 ins. thick. This job is standing to-day without a crack or settlement, vindicating the judgment of the engineers in using this type of construction.

Mr. Gow refers in his paper to the use of reinforced concrete piles in wharf construction. There has been driven within the last two years, at Delara, Peru, a reinforced concrete pile wharf, some details of which were rather interesting.

This wharf was built in open water, using concrete piles driven to bedrock. As the material overlying the rock was constantly shifting, owing to the action of the currents and heavy sea, the rock was at times exposed, not offering any secure anchorage for the point of the pile. This difficulty was overcome by adopting the following method: The pre-cast pile was cast with a 2-in. pipe the whole length set in the center or long axis of the pile. After curing a specified time, the pile was taken from the casting bed and hoisted into the gins for driving. The piles were driven in the usual way to refusal, then they were stay-lathed to hold them in position. A steel drill rod with bit was lowered down the 2-in. pipe in the pile. This bit was churned up and down until a hole several inches deep was drilled in the rock. This drill was then removed and a steel pin was dropped down in the 2-in. pipe and grouted, thus pinning the point of the pile to the rock.

Mr. Linton Hart.* — Mr. Clarke spoke on the use of pre-cast concrete piles. We drive a great many such piles, notably in the district about Baltimore and in the southern waters where the concrete is not affected by the freezing action of the water due to the porosity, as might possibly be the case in northern waters when due care is not taken in making a proper mix to prevent undue porosity. These piles have been made in various shapes and sections, reinforced in different ways according to the handling they were to have and the use to which they were to be put. Some of the longest of these that have been driven in Baltimore waters were made 18 ins. square and 61 ft. long; they were driven for the foundation of a concrete pier at the United States Naval Academy, Annapolis, Md.

Mr. Clarke also spoke of pinning pre-cast piles to rock by drilling into the rock and dropping a cast-steel pin through a hole left in the center of the pile down into the hole drilled into the rock. This method was used to a considerable extent in the concrete sheet pile bulkheads along the New York State Barge Canal Terminus, and also used with considerable success in Chicago at the plant of the Sefton Manufacturing Company, on some bulkhead construction there.

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* Representative of the Raymond Concrete Pile Company, 53 State Street, Boston.

Mr. Gow has brought out in his photographs an illustration of a pile-casting plant used by William L. Miller, of Boston, on his work for the Recreation Pier in Baltimore. This method of making up forms in one place, casting the piles and then, after they are set, moving them to the storage pile, has advantages which I do not think were brought out by Mr. Gow. We are now casting some piles by this method for use at the Bethlehem Steel Company's plant at Sparrows Point, Md., and we find that, due to the use of that particular system of casting, the seasoning process is speeded considerably over the other method of handling pre-cast piles, which is known as the "En Block" method. In this method, alternate piles are cast, and, after being stripped, a film of heavy grease is painted hot over the surface between the piles, thus preparing a form for the piles which are cast in between, the distance between the sides of the piles first cast being equal to one dimension of the pile. It is easy to see that where the surface of the cement is filled with a heavy hot grease like this, and one pile cast alongside and another cast on top, that the seasoning process is considerably held back.

In regard to cast-in-place concrete piles, there are three types, as you have already been told, which are commonly used in this country. These are the Raymond pile, which was the first to be developed; the MacArthur or Pedestal pile; and the Simplex pile. The advantages of the Raymond system consist in the speed with which the work can be done, the ease of inspection, the fact that every pile can be properly inspected from top to bottom before a load is superimposed, and the fact that the steel shell which is left in the ground prohibits undue strains on the shaft of green concrete, due either to back pressure in the ground or to the driving of adjacent piles. Dirt and other extraneous matter is prevented from mixing with and weakening the concrete which is to carry the load.

We have recently been experimenting with a new type of pile which Mr. Gow has not spoken of, known as the Composite Pile, which we have gotten up in order to enable us to reach to any depth. There have been composite piles driven previous to this as combinations of a wood pile with an unprotected concrete column made in somewhat the manner that the Simplex and MacArthur piles are made, but this pile of which I speak is a combination between a Raymond pile and a wood pile. The joint between the concrete and the wood is made solid with bond bars which are driven into the wood and set also into the concrete, and tests have shown that the strength of this joint is about 70 per cent. of the resisting moment of the wood pile 2 ft. below the joint. There is no economy in the use of such a pile where a concrete pile from 30 ft. to 40 ft. long could be used instead, and the loads used differ materially with the kind of soil through which the concrete shaft and the wood shaft are driven. We have driven a number of these piles in meadows of New Jersey where they have gone down to 50 ft. or 60 ft., and they have been tested to a load of 120 000 lbs. with very good results.

The Composite pile is not a new idea in itself, but the use of a Raymond shell to form the concrete column on the top of the wood pile is a development of the early types of composite pile driven, and an improvement on them.

In regard to the tubular pile which Mr. Clarke has just spoken of, it may be interesting to know that the old New York Postoffice, which is built on stone footings, now entirely stands, for its whole uptown end, on piles of this kind.

This work was done by Frederick L. Cranford, Inc., of New York, under the direction of Mr. James C. Meem. These piles have all been jacked down to sand, using the columns of the old postoffice to jack against, and then have been dug out and filled with concrete. In digging out these piles they used a miniature orange-peel bucket which has been developed for this particular purpose. Each of these piles after having been concreted and set for a proper length of time has been tested for load by an hydraulic jack, and it has been found that there is an initial settlement varying from a fraction of an inch to considerable settlement before finding solid bearing. This initial settlement has been taken up by the jacks on all piles underneath this building, and I think that Mr. Meem will have some very interesting reports to make on the results obtained on that particular type of pile when this particular section of subway work is finished.

Mr. Harry E. Sawtell.* — Mr. Gow's paper is admirable and will help us to gain a better understanding of this important subject.

It seems reasonable to assume that the greater part of all concrete piles used are uninjured and doing the work imposed upon them, as a great many important structures are safely supported by them.

It can also be assumed that most groups of any kind of piles contain some which are not good and which do not perform their part of the work; and yet how many designs include extra piles to make up for this condition?

It is seldom done, owing to the expense of added piles and to the uncertainty of the number which may be bad.

In order that the number of bad piles may be reduced to a minimum, it would seem necessary to gain a thorough knowledge of the soil by means of borings rather than to trust to test piles; to select the proper pile for the place and to give the construction work thorough supervision.

The need of exploration of the soil cannot be stated too strongly, as a knowledge of the soil reduces the largest factor of uncertainty to a minimum.

When selecting piles for soils having a compressible or plastic nature, such as medium or soft clays, some sands, etc., it should be kept in mind that settlement must be expected more or less continuously, and that the settlement can be reduced considerably by spreading all loads over large areas, thus reducing the unit load.

This can often be accomplished better by using a greater number of wood piles having one half to one third the value of concrete piles.

If properly selected and driven, there seems to be every reason to expect as small if not a smaller percentage of poor wood piles than poor concrete piles.

The fact that bad piles are probable in all types of cast-in-place or driven piling makes the " safety factor " or " degree of security " all the more important.

It is the custom in Mr. Chas. T. Main's office to have load tests made whenever possible, in order to assist in the determination of values. It seems desirable in most designs for first-class structures to get piles having practically no settlement under working load, and a limited settlement under two and one-half times the working load. This maximum may vary from $\frac{1}{4}$ in. to $\frac{3}{4}$ in., depending upon the character and occupancy of the building.

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* Structural Engineer, with C. T. Main, 201 Devonshire Street, Boston.

It is also our custom to note the change in settlement of a pile being tested when both putting on and removing an amount of load equal to the total live load which may be added or removed from the building in service.

If all piling is placed with care, and a safety factor of at least $2\frac{1}{2}$, as above defined, is obtained, we can feel quite sure that if a small percentage of bad piles has been driven, no marked settlement or failure will be obtained.

For medium clays, which are found in a great many places in New England, we have found that the best guarantee against troublesome settlements is a deep embedment of the pile.

Mr. Gow speaks of the protection afforded by the shell, of the Raymond type of pile, against lateral strains in the soil, but we have found that even these piles have become occasionally distorted before the concrete has set hard.

This is liable to take place at the level of a practically incompressible stratum of soil by the driving of successive piles.

It is my opinion that to gain a greater degree of security, piles should be spaced at least 3 ft. center to center, and more if it is thought desirable to develop the full strength of the soil.

The driving of built-in-place piles should be arranged so that successive piles produce the least lateral pressure on newly poured piles.

Mr. John T. Scully.* — I do not want to make any statements that would in any way convey the idea that I am trying to advertise our proposition, but since the representative of the Simplex has spoken in regard to the paper, I would like to state one or two features that are particularly important to me, and particularly interesting to me, and I think would be interesting to the gentlemen here, in reference to the MacArthur concrete pile — the pedestal pile — which I represent in Massachusetts.

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* President John T. Scully, Inc., 185 Devonshire Street, Boston, representing the MacArthur Concrete Pile and Foundation Company.

I had been identified with the wooden pile driving for some forty years or more, and, seeing the trend of events, I felt that if I were to continue in the piling and foundation business, it would be necessary for me to follow along the lines of a concrete pile proposition, and for a year and a half I have been identified with the MacArthur concrete pile.

The method of driving is somewhat different at the present time from that which was shown on the screen. We use in most cases the cast-iron point with the 16-in. diameter shell, and the plunger in the inside which does *not* extend beyond the shell. It is the same length as the shell. The shell and the plunger are driven together.

When the proper stratum is reached, the plunger is withdrawn and a small batch of concrete is put into the tube; then we replace the plunger. We notice this, that the plunger is perhaps 3 ft. out of the shell. We then raise the shell 6 ins. or perhaps a foot and then drive with the steam hammer, and the concrete is driven out of the tube. Where the strata is comparatively soft, it goes quite easily. The softer the strata, the more quickly the concrete takes its shape.

After the bulb is formed, we then fill the shell full of concrete and place the plunger — weighing with the hammer on top four or five tons — on top of the concrete and withdraw the shell. The weight of the plunger simply tends to force the concrete into place and prevent it arching, which to my mind is one of the most important features of the MacArthur concrete pile. We have the bulb that has been made and we have the weight of the hammer on the concrete which holds it down and prevents it from arching while the shell is being withdrawn.

Some time ago there were some interesting experiments performed at the Pennsylvania State College to determine the distribution of the forces set up in the earth due to a bearing pile transmitting its load to the soil.

Lines of force were drawn through points below the pile where the resistance to the pile load were of equal unit value. Of course the line showing the greatest unit resistance was a straight line directly below the center of the pile, but the lines showing the lesser unit resistance took a bulb shape from the tip of the pile. The line showing the least unit resistance included all the lines of greater unit resistance. This line was an exact duplicate of the shape of the MacArthur pedestal; and leads me to suggest that if, under the ordinary 14-in. or 16-in. concrete pile without the bulb, the lines of resistance set up in the earth take the shape of the MacArthur pedestal, how much greater the resistance when the concrete bulb is put in.

I think that in the concrete pile business we have all profited by the mistakes of the past and that we know, not from experiment but from actual results, pretty closely what the pile will stand.

Mr. R. A. Hale.[*] — In driving through sand and gravel containing small bowlders, I should like to inquire how they overcome the difficulties on striking a bowlder which cannot be moved easily.

Mr. C. R. Gow.[†] — I believe that you will experience the same trouble from such a cause whatever the type of pile, whether wood, concrete or steel. If the bowlder is of sufficient size to resist lateral displacement, the pile point is reasonably sure to stop at that elevation.

Regardless of the attractive advertisements which frequently describe how steel piling and other types are driven through bowlders and even into solid rock, I have yet to be convinced that such action ever occurs except perhaps in a few instances where the rock is soft or more or less disintegrated.

The best method which I know of for displacing bowlders below the surface of the ground is that of utilizing the water jet.

In making test borings through coarse gravel we frequently encounter stones too large to permit of their being washed up through the pipe. By working the wash drill past them and eroding the fine material from below, it is sometimes possible to drop these stones down into the cavities thus formed.

In the construction of the foundations for the new Thames

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[*] Principal Assistant Engineer, The Essex Water Power Company, Lawrence, Mass.

[†] Author's closure.

River Bridge, at New London, Conn., now under way by the Holbrook, Cabot & Rollins Corporation, it has been necessary to sink some very large open caissons to a maximum depth of 140 ft. through silt and gravel. They are sunk by dredging with grab buckets through open pockets. Occasionally a bowlder is encountered which is too large for the bucket to handle.

To displace such bowlders, Mr. Rollins has installed a jetting apparatus of unusual size. A 1 200-gal. fire underwriters' pump operated by a 250 H.P. boiler delivers water to a 4-in. jet pipe at the rate of about 1 000 gals. per minute under a pressure of 150 lbs. per square inch. When this apparatus is operated and the jet pipe — handled by a derrick on lighter — is lowered alongside of a bowlder, a large cavity is at once created into which the bowlder rolls. By repeating the operation for a few minutes the bowlder can be buried to a depth of 15 or 20 ft. below its original position.

If bowlders encountered in the driving of piles cannot be removed by this method or by blasting, it will usually be necessary to drive another pile alongside at a sufficient distance to clear the obstruction.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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LINES AND GRADES IN TUNNELS OF SMALL DIAMETER.

By Henry B. Pratt,* Member Boston Society of Civil Engineers.

In the construction of two tunnels for the Edison Electric Illuminating Company of Boston, one under Fort Point Channel and the other under the Reserve Channel, it was found difficult to give lines and grades in the usual manner, with the transit set up on the tripod, owing to the fact that the diameter of the tunnels, which was only 7 ft. on the inside, did not permit of setting up the instrument without stopping the passage of cars on the construction track. The delay caused by stopping these cars was very serious, as it often meant that the whole gang on that end of the tunnel, not only in the heading but also in the shaft, lock and head house, was obliged to suspend operations until the cars were given free passage.

In order to avoid this delay a method was devised by which the instrument could be attached to the roof of the tunnel in an inverted position (see figure), allowing the passage of the cars beneath, the clearance between the top of the cars and the lowest part of the transit being about one foot. In order to use the instrument in this manner it was necessary to so arrange the level tube that the bubble could be seen when the instrument was upside down and the vertical arc in its normal position. A Buff transit was used, equipped with a 180-degree vertical arc, and after having the instrument put into good adjustment it was set up on the tripod, the telescope leveled, and a horizontal line marked about 50 ft. distant, coinciding with the horizontal cross-hair in the instrument, with the vertical arc reading zero. The level tube beneath the telescope was then removed and replaced in an inverted position, the telescope rotated vertically so as to bring the level tube over the telescope with the graduations uppermost, and the level tube so adjusted that when the cross-hair was on the mark the bubble was on center. Now by rotating the telescope back to its normal position and setting

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* Assistant Engineer, J. R. Worcester Company, 79 Milk Street, Boston, Mass.

Note. This paper will not be presented at a regular meeting of the Society, but discussion is invited, to be received by W. L. Butcher, Editor, 14 Beacon Street, before January 10, 1918, for publication in a subsequent issue of the Journal.

Transit in Inverted Position

the vertical arc on zero, the telescope was brought perpendicular to the vertical axis of the instrument with the bubble on center, although not in a readable position until the instrument was turned upside down. If the transit were equipped with a complete vertical circle, this same object could have been accomplished by rotating the telescope vertically 180 degrees from normal and clamping with the vertical arc, reading that figure which would bring the bubble into a readable position when the transit was turned upside down.

Wooden blocks about 8 in. square were built into the roof of the tunnel as the work progressed, being placed at intervals of about 200 ft. To these blocks were attached metal sockets, such as the transit is screwed to when cased, care being taken to set them approximately on line. When giving line in the tunnel, the transit was screwed to one of these sockets, the vertical arc was set on zero and the instrument leveled by using leveling screws and observing the telescope bubble, which was now above the telescope with the graduations uppermost. It required some practice to level the instrument, as the screws had to be turned in the opposite direction from what they would be if the transit were in an upright position. The instrument was revolved horizontally in leveling, in the same manner in which a Wye level is revolved when being set up. In order to bring the transit on to the exact line, it was slipped laterally on the sliding head and brought on to line by observing two points which had previously been accurately established farther back in finished tunnel. The telescope could now be rotated vertically and line given ahead in the usual manner. After bringing the instrument on to line, a plug was set in the side of the tunnel at the level of the telescope and an offset read to the center of the instrument in order that the transit could be set on line at any other time without making observations.

When giving grades the telescope was leveled, the height of instrument determined and rod readings taken in the usual manner. After once obtaining the height of the instrument on a "Set-up" on any particular socket it was found that the instrument would be near enough to the same height on successive set-ups on this socket to allow of giving grades without a further reading on the bench except in the case of establishing a bench ahead.

In order to prevent wear between plates of the transit due to the liability of particles of dirt working into the joint, the two plates were kept constantly clamped. As a further precaution, some heavy grease was run into the joint so that when the transit was screwed to the roof of the tunnel particles of mortar which would fall on the instrument would be prevented from working into this joint which was then exposed. As the tunnel in which this method was used was straight, there was no occasion to turn any angles or to set the instrument on a point, correct both for line and distance. If it were necessary to run out a curve using an instrument in this manner, it could be accomplished by giving tangent offsets, instead of reading angles, which would be somewhat difficult to do with the instrument upside down. If it were required to set the instrument correct both for line and distance, it could be done by setting two offset plugs, one on line with an offset for distance, the other at right angles to line with an offset to line.

In using a transit in this manner it is well to tighten the nut at bottom of spindle, so as to take up the play between the plates and also to make the instrument secure, as almost the whole weight of the transit is carried by this nut.

This method of running lines and grades was found to be very satisfactory, as the engineers were enabled to do their work without feeling hurried, as they would have felt if they knew that they were causing the contractor a serious delay. The writer is indebted to C. W. Alexander for his able assistance in perfecting this method of tunnel survey.

MEMOIR OF DECEASED MEMBER.

STANLEY ALFRED MILLER.*

DIED MAY 13, 1917.

STANLEY ALFRED MILLER was born in New Orleans, La., on May 27, 1882. He was educated at local schools and at the Louisiana State University.

He passed through the grades of rodman, levelman and instrumentman and became assistant engineer on sewers, levee work and railways, and when nineteen years old was assistant engineer to the Board of Public Works of Mobile, Ala.

As assistant to various consulting engineers he was employed on the survey, design and construction of sewers and water-works for Baton Rouge, La.; Mobile, Ala.: Dallas, Tex., and Ardmore and South McAlester, Okla.

In 1904 he was resident engineer on the Chihuahua & Pacific Railroad, and in 1905 was with S. Pearson & Son, Ltd., on port works at Puerto, Mexico. Next he worked for the Mexican Light and Power Company near Necaxa, Mexico, in 1906, in charge of Earth Dams Nos. 1 and 3 and Tunnel No. 1.

He constructed a seven-mile sewer for Paducah, Ky., and paving and sewerage for Cairo, Ill., in 1906 and 1907, and was assistant engineer on hydroelectric projects in California and Colorado in 1907 and 1908.

For the next three years he was in charge of the Azua Irrigation Survey in Santo Domingo. The writer helped him pick assistants for this work, and visited him several times during its progress. It was very hard work, all supplies and water having to go by pack train. The work was finished in spite of revolutions and other troubles.

He next took charge of the location of fifty-five miles of improved highways for Copiah County, Mississippi, and the construction of a part of the work. He then went to the Argentine Republic, and then entered the employ of the Uruguay Railway Company, in charge of railway location and construction, and the building of a reinforced concrete wharf.

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* Memoir prepared by William H. Balch, who states that he has taken his facts largely from the able memoir of Mr. Miller by Mr. Vernon L. Havens, Proceedings of American Society of Civil Engineers, August, 1917, p. 1407.

From October, 1914, to December, 1916, Mr. Miller was engaged in general consulting practice at his home in Paducah, Ky. He designed sewers for the city, and reported on drainage projects in Kentucky, a hydroelectric plant in Mississippi, and rates for a public utility corporation. He became well known in Kentucky through his earnest efforts to improve the status of the engineer and to increase the interest in good roads. He built up a good practice, which was continued during his last absence in Santo Domingo.

In December, 1916, he sailed to La Romana, Santo Domingo, to " study a couple of rivers for hydroelectric and irrigation development " for the South Porto Rico Sugar Company at Central Romana. This work, like his previous work in Santo Domingo, meant living in a camp at a distance from the town and plantation. It was an unexpected pleasure to the writer to meet Mr. Miller at La Romana on April 8, when he delayed his return to camp so that we could have a long talk. We planned for the writer to visit the camp, when his work permitted.

On April 15 Mr. Dillingham and Mr. Maxwell, of the South Porto Rico Sugar Company, visited his camp, with a party including Miss Dillingham and Miss Davis. On May 13 we were shocked to hear that Mr. Miller and his assistant, Mr. E. Hawkins, had been killed in camp early that morning by bandits. We could not believe it was true, but a party under Lieutenant Hunter, U. S. M. C., with Dr. Watkins (formerly surgeon, U. S. A.), found the report true and were able only to burn the bodies and return to La Romana.

Mr. Miller and Mr. Hawkins were killed as an act of wanton revenge by a band of over one hundred (220, when captured, according to official report) outlaws, on account of losses they had sustained in conflict with United States marines. The outlaws rushed his camp in the early morning and took the men away, killing them about an hour later. Mr. Miller explained to the bandit the nature of his work and its non-military character, but the reply was, "Los Americanos están buscando mi vida, y yo voy á tomar la suya." ("The Americans are trying to take my life, and I am going to take yours.") His last request, that he be permitted to write to his wife, was denied.

He met his death bravely, as a soldier of the world's advance. Only the future can show us how very important was his work of helping increase our sugar supply at a critical time. His loss will be most keenly felt by all his associates and acquaintances, to whom his high ideals had always been an inspiration.

Mr. Miller was married to Miss Ann Bradshaw, of Paducah, Ky., who, with their daughter, Stanley Ann Miller, born six weeks before her father went to Santo Domingo, survive him. He is also survived by his father and mother, Mr. and Mrs. W. R. Miller; his brother, Mr. W. R. Miller, Jr., and his sister, Mrs. W. Molton Evans, all of Baton Rouge, La.

Mr. Miller was a member of the New England Water Works Association, American Society of Civil Engineers, Boston Society of Civil Engineers, Sigma Alpha Epsilon fraternity and Rotary Club of Paducah.

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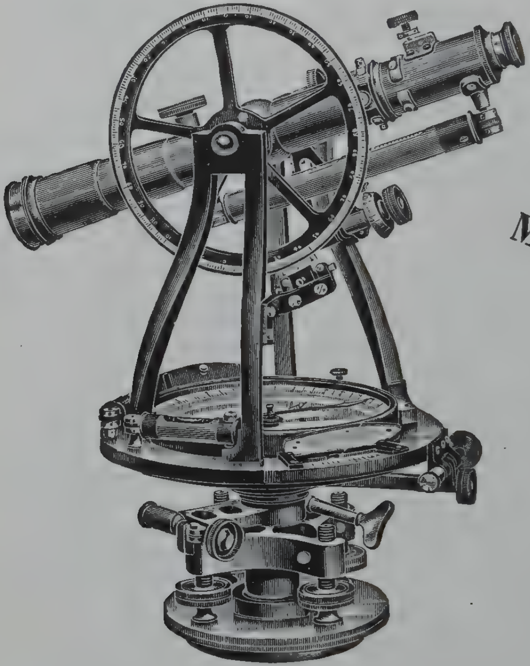

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